# POWER

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## Who Pays the Freight?

WHEN the wages of labor are increased, who pays the bill?

If the products of labor are sold at cost plus a fair profit, it is the purchaser of the goods or service.

The employer, in this case, would add the increase in wages to his cost, figure his profit on this greater sum, and both he and the workman would make more money

But they would have to pay more for this particular product or service; and if the increase were general and extended to all kinds of labor, everybody would have to pay proportionately more for everything and nobody would be any better off. Those who were living on fixed incomes would be out of luck. The purchasing power of savings put by for old age or a rainy day would be impaired.

If things are sold at what the market will bear, regardless of cost, then it is a scrap between the manufacturer and the labor which he hires as to the share that each shall get of the money that the purchaser can be wheedled or coerced into paying.

Unhappily, it is upon this basis that industry is conducted and most business done.

The workingman has no means of knowing what share he gets of the products of his labor. The purchaser does not know what proportion of the dollar that he pays goes to labor and what to the employer. He knows that no business can be continuously conducted at a loss, but he does not know, and he cannot find out, how much he is paying through the indirect and circuitous channels of trade for the service that is rendered to him by the workingman, by the capitalist and by the brains which conduct the enterprise.

Costs and profits are the guarded secrets of industry and trade.

And so we are drifting into a series of struggles between different classes of labor or between each class and all the rest, for it is all the rest who constitute the purchasing public and are the purchasers and users of the labor of and, in the last analysis, the paymasters of the one.

By extensive organization the members of the building trades enforce their demands for wages away above those paid for labor requiring an equal amount of skill and preparation. As a result everybody who rents a house or an office or buys anything in the manufacturing, warehousing and sale of which buildings of any kind are involved pays the price.

The coal miners and the operators are getting together in a secret conference. No user of coal or of the products in the manufacture of which coal is used wants a miner to work for less than will support his family the year around in the way they ought to live, with a surplus for his declining years. And nobody expects the owner or operator of a coal property to work it at less than a fair profit.

The public is willing to pay this price to each; but it wants to know to whom it is paying it and what it is getting for it.

And for this price the public has the right to continuous, dependable service from both producers and miners.

F. R. Low

# Rebuilding a Large Boiler Plant Without Interrupting the Service

By ALFRED IDDLES and J. WALTER MAY*

**A MODERN boiler plant, containing five water-tube boilers, each of 4,900 square feet of water-heating surface, was built on the same location as an old, obsolete and overloaded plant, containing seventeen hand-fired horizontal return-tubular boilers, without interfering with the capacity of the plant and without interruption in service supplied to a large textile-bleaching, dyeing and finishing mill.**

SITUATED in the outskirts of Norwich, Conn., on the Shetucket River, is one plant of the United States Finishing Co., which is engaged in bleaching, dyeing and finishing cotton cloth. The power requirements are supplied partly from a water-power development of the Shetucket River and partly from steam generation. The boiler plant is also required to furnish a large amount of steam for process purposes.

Because of the age of the power plant, particularly the boiler room, the rising cost of coal in this territory and the increasing complication of steam and power requirements, a remodeling of the plant became necessary. In 1920 Day & Zimmermann, as consulting engineers, were directed to make a power survey of the entire mill, with particular reference to the possibility of remodeling the steam and power-generating equipment. This survey was also to include a study of possible economies throughout the mill in the use of steam and power and to consider the requirements with reference to future growth.

Steam was supplied by an old boiler plant (Figs. 2 and 3), part of which was 27 years old and part 21, consisting of 12 return-tubular boilers, shown on the left, and a battery of 5 more return-tubular boilers on the opposite side of the firing aisle, making a total of 17 in all. These boilers were hand-fired on stationary grates, but supplied with forced draft, and coal was brought to the boilers in one-ton cars from storage at either end of the boiler room, through tunnels under the adjacent road and adjacent warehouse building. The survey indicated, first, that it would be necessary to replace the old boiler plant in the immediate future because of depreciated physical condition of the entire equipment. It also appeared desirable to remodel the entire steam and power production system of the mill, in order to effect economies by the installation of modern machinery. A study of the steam- and electrical-distribution systems indicated that the present location of the boiler plant was the best one available, therefore it would be desirable to construct the new plant on the same site.

As a result of these recommendations it was decided to begin at once the construction of a new boiler plant and to plan at the same time the construction of a turbo-generator power plant, with provisions for using exhaust steam for process work in the mill.

In order to accomplish this, a more detailed survey was made of the immediate surroundings of the old boiler plant; for the engineers were confronted with the problem of creating, on the old site a new boiler and turbo-generator plant of sufficient capacity to handle present and future requirements, and at the same time maintain continuity of operation in the mill. This involved the construction of the new plant before the demolition of the old. A study of the site also indicated the desirability of utilizing the present brick stack both for reason of cost and because there was no space available for the erection of another, even though the existing one was too small for natural draft for a new plant.

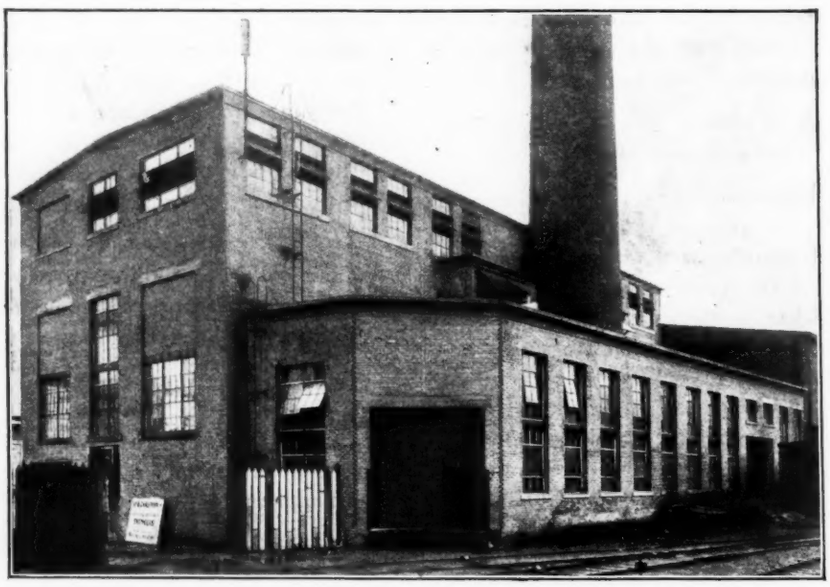

FIG. 1—REMODELED POWER PLANT: BOILER-ROOM ON THE LEFT, TURBO-GENERATOR ROOM ON THE RIGHT

The site is surrounded, on one side by a canal, on the second by an adjoining warehouse building, on the third by tracks of the New York, New Haven & Hartford R.R., and on the fourth by a narrow roadway that crosses the railroad tracks and the canal. It became necessary, therefore, that the new plant must be constructed in this limited space, over and around the old plant, while the latter was in operation; to use the

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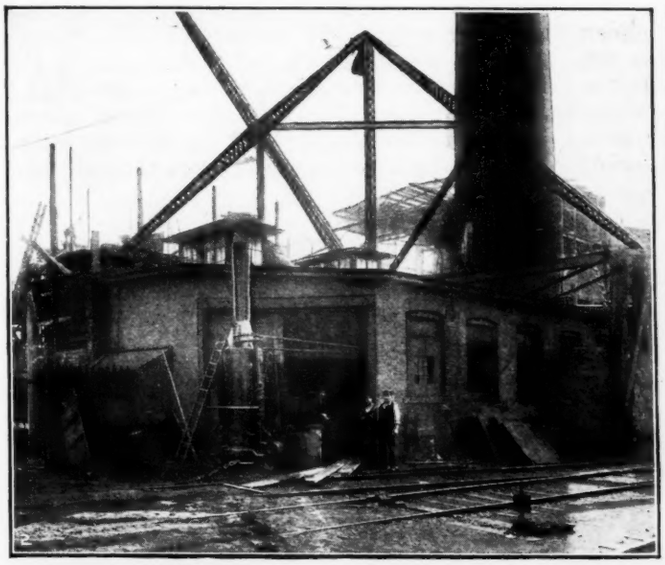
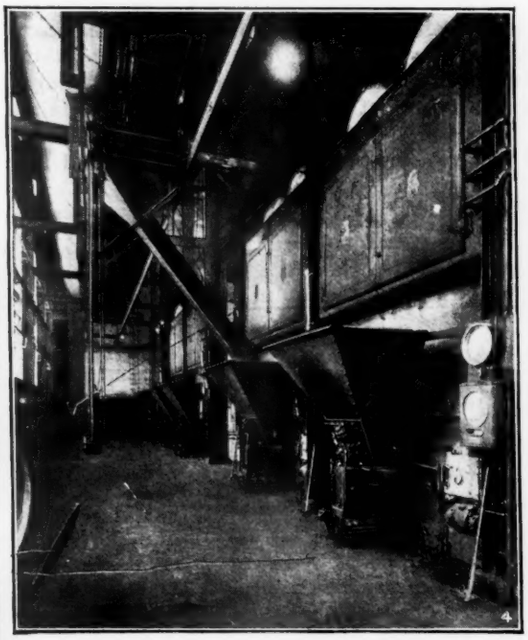




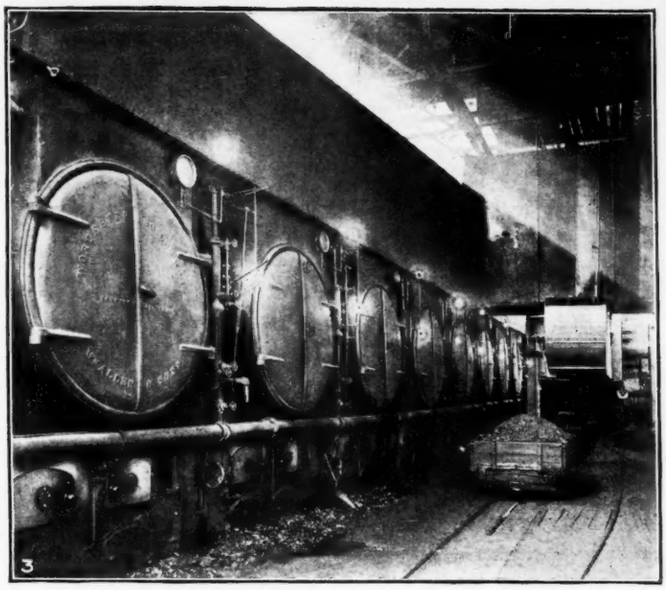
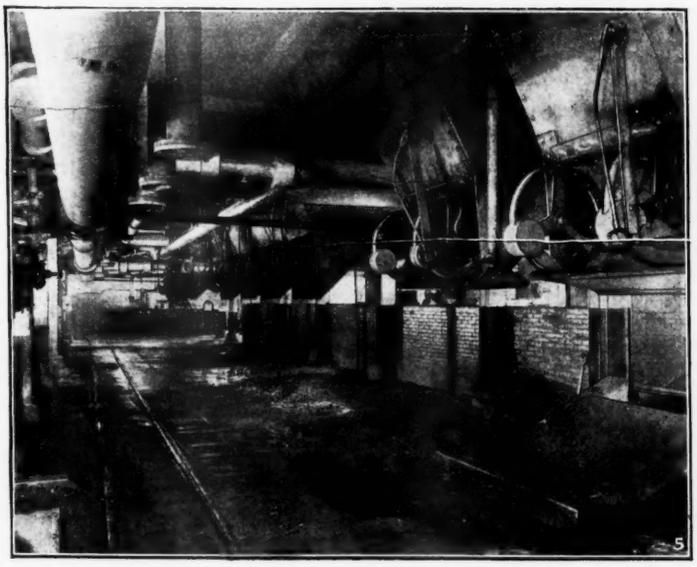


Fig. 4—New boiler-room firing aisle with 5 boilers, a suspended steel coal bunker and traveling weighing larry. Each of these boilers has 4,903 sq.ft. of water-heating surface. They are located over the 12 old boilers shown on the left (Fig. 3). The first new boiler installed was erected and put into operation while the old boilers below were kept into service.

Fig. 5—Basement of new boiler plant. Ash hoppers and forced-draft duct have been built in the space occupied by the old boilers. Forced-draft duct is back of brick wall seen on the right under the ash hoppers. Coal is brought into the basement on a car and dumped into a track hopper, from which it goes to a crusher and then to an elevator, which delivers it to the bunker.

Figs. 2 and 3—Exterior and interior of old boiler plant before rebuilding. Part of this plant was 27 years old and part 21 years, and consisted of 12 return-tubular boilers shown on the left (Fig. 2) and 5 return-tubular boilers on the opposite side of the firing aisle. The boilers were hand fired on stationary grates, but supplied with forced draft, and coal was brought to the boilers in one-ton cars from storage at either end of the boiler room, through tunnels under an adjacent road and warehouse building. Space limitations made it necessary to build the new plant exactly on the site of the old one. The cramped quarters available compelled the erection and operation of a steel stiff-leg derrick, located on the roof of the old boiler-plant, to handle all of the material for the building and the erection of some of the mechanical equipment in the new plant.



present foundations and outline of the old building as far as possible, and at a minimum cost.

In general, the conclusions arrived at were to build a new boiler plant over the old one, making the floor of the new plant slightly above the tops of the old boilers and using the space occupied by the latter for the basement of the new plant. Load conditions made it necessary to construct and put in operation new boiler capacity before any old boilers could be removed.

A second-hand steel-plate fan was found idle in the mill and, together with a belt connected motor, it was moved to the basement of the warehouse adjacent to the boiler room. The discharge of this fan was connected to the stoker by a steel duct passing above the new boiler-room floor line, therefore above the tops of the old boilers. The duct then passed through the rear combustion chamber of the new boiler with proper protection against damage by heat, through the bottom

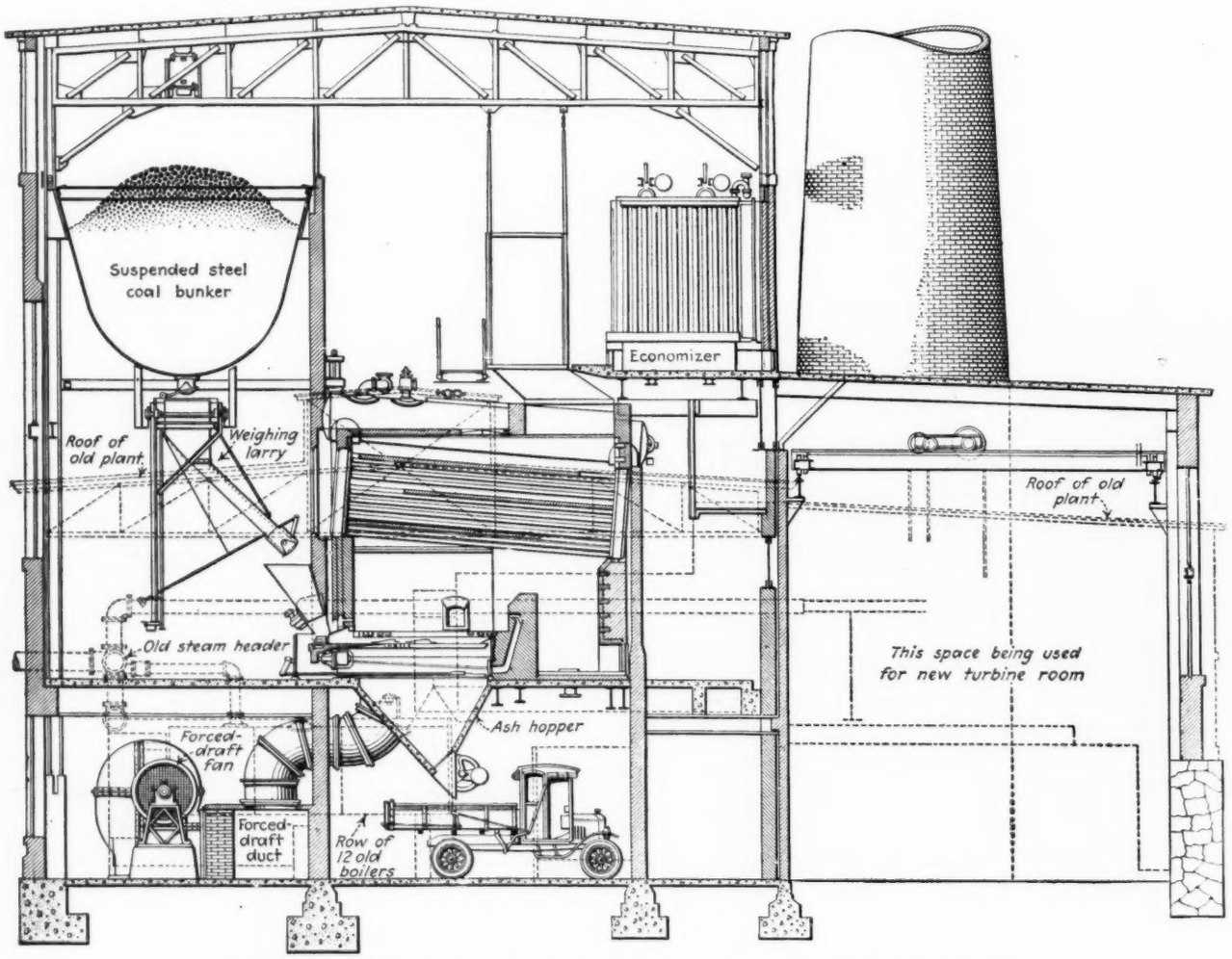



FIG. 6—SHOWS HOW NEW PLANT WAS CONSTRUCTED OVER OLD BOILER PLANT

It was, therefore, decided to do the new work in three stages:

1. Install a new boiler over and above three old ones while the latter were still in operation.

2. Remove the three old boilers adjacent to the first new one, erect a battery of two new boilers in this space and put these two in operation.

3. Remove nine old boilers and then put in operation the last two new ones.

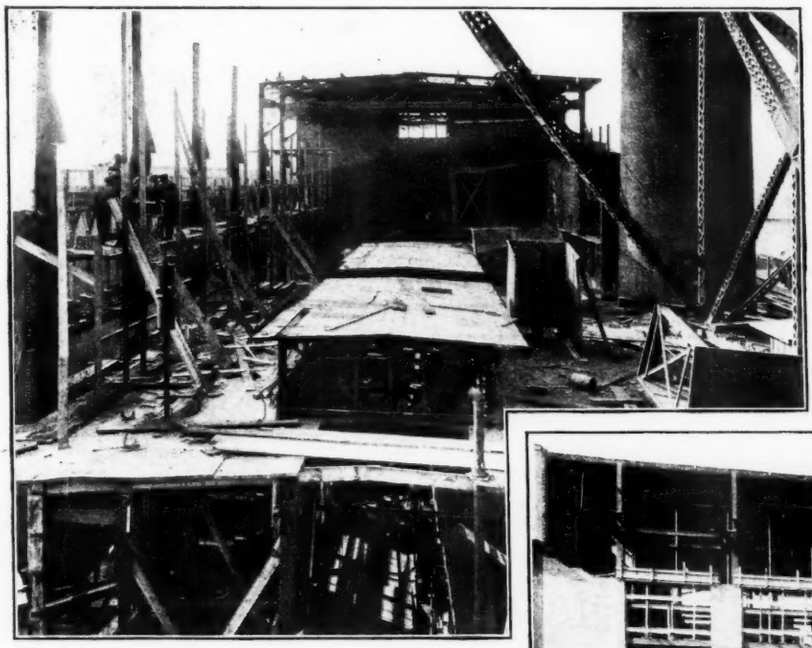
If underfeed stokers were installed under the new boilers, the normal supply for forced draft would be from fans placed in the basement with the air transmitted through brick and steel ducts to the stoker windboxes. However, this space in the basement was occupied by old boilers that must be kept in operation. Plans were made to provide the first new boiler, known as boiler A, with temporary forced draft which could later be removed and the permanent connections made. of a specially constructed bridge wall and finally into the rear end of the stoker windbox. The smoke from the old boilers, 10, 11 and 12, was to be temporarily cared for by a flue at a lower elevation, running from these boilers to the main smoke flue near the stack. On the new boiler temporary steam and feed-water connections were to be made and temporary provision for elevating coal and removing ashes.

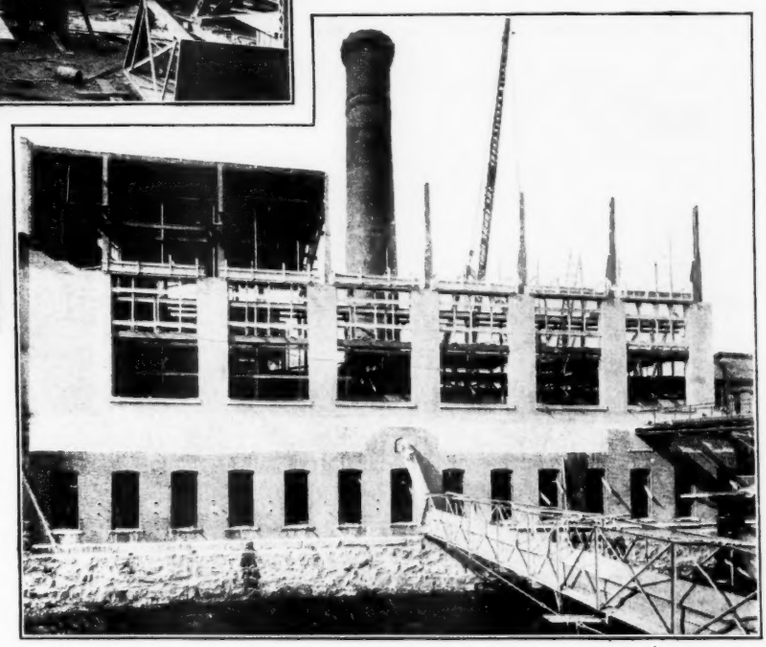
At the same time that the first new boiler was being constructed, the old building was to be changed by raising the walls, installation of a new steel framework inside of the present building, construction of a new roof at the proper elevation for the new plant and then by removal of the old roof.

This general construction program, it was believed, would accomplish the purpose in mind and permit the final completion of a new plant of five water-tube boilers, each having 4,900 sq.ft. of water-heating sur-

face, with available space for a sixth new boiler; together with underfeed stokers, coal and ash handling equipment and necessary forced-draft, induced-draft and pump auxiliaries; and a suspended steel coal bunker over the firing aisle with a traveling weighing larry distributing coal to each boiler. In the rear of the boilers two economizers with necessary smoke flues and induced-draft fans are installed between the boilers and stack. Fig. 6 is a cross-section of the completed plant, and a comparison with Fig. 2 will show how the new station was superimposed over and on the old plant.

The cramped quarters available made it necessary carefully to plan a construction plant, and arrangement was made with the structural-steel contractor to furnish, erect and operate a steel stiff-leg derrick located on top of the old boiler plant roof. This derrick was supported by wood bents passing down through the old building to the ground. One leg was counterweighted by bricks and the other lashed to the old brick wall. Fig. 2 shows this derrick in place, and from it can be gained an idea of its usefulness. It was used not only to erect the structural steel, but also for the erection of some of the mechanical equipment, before the roof was closed in, and for the hoisting of all brick, lumber and mortar used in the construction of the new building. In so far as possible all structural steel was shipped so that it would arrive when needed and so be handled directly from the cars to the building. Similar arrangement was made for handling the first boiler and its stoker.





FIGS. 7 AND 8 — SHOW HOW THE NEW PLANT WAS CONSTRUCTED OVER THE OLD ONE. THIS CONSTRUCTION RAISED THE LEVEL OF THE ROOF ABOUT 31 FT. AND NECESSITATED THE CONSTRUCTION OF NEW BRICK WALLS ON TOP OF THE OLD ONES, WHICH WERE TORN DOWN TO A POINT WHERE THEIR CONDITION WAS SATISFACTORY

Investigation had shown that the old stone foundation wall along the canal side of the boiler plant was in good condition. On top of this a reinforced concrete girder was placed, inside of the old building line, and provision made for erecting on this concrete girder the steel columns for one side of the new building.

Temporary openings were made in the front doors of the old return-tubular boilers, Nos. 10, 11 and 12, and to these openings was connected a temporary sheet-metal flue at an elevation just above the heads of the firemen. This flue was carried horizontally to the main smoke flue and connected near its entrance into the stack. This permitted cutting off the old smoke flue between old boilers Nos. 9 and 10, and the removal of this end section, thus leaving clear the space above the shells of old boilers Nos. 10, 11 and 12.

At the same time that the concrete girder was being built along the canal wall, excavation for new column footings was made in the old firing aisle, likewise temporary footings installed as close to the front of boilers 10, 11 and 12 as possible. Over these three old boilers new floor beams were erected. These beams were designed to carry the new boiler with their two ends supported on permanent columns, but with a permanent column at the center of the span temporarily omitted, its place partly taken by the temporary columns immediately in front of the old boilers. This new floor structure was built as close to the top of the old boilers as possible, in order to keep to a minimum the height of the new building. Because this floor was so close to the old boilers, it was necessary temporarily to close the openings in the concrete floor provided for the ash hoppers and to bring into the the first new boiler temporary forced-draft connections above the floor level.

While the concrete floor for the first boiler was being constructed, the building columns for this section of the new plant were erected and the new roof built. As soon as this new roof was closed in, the old one was

removed to provide an open space above the new boiler room floor for erecting the first new boiler. This construction raised the level of the roof about 31 ft. and necessitated the construction of new brick walls on top of the old, which had been torn down to a point where their condition was satisfactory (see Figs. 7 and 8). At all times there was roof protection of some kind over the equipment below.

To support the west end of the roof trusses for the first boiler, it was impossible to erect columns down to ground level, because of the five old boilers on this side of the firing aisle. Therefore, a pair of 48-in. steel girders were placed, with one end supported on the south building wall and the other on a temporary steel bent adjacent to the stack and carried down to permanent column footings. Later, the temporary bent was removed and a permanent column installed in its

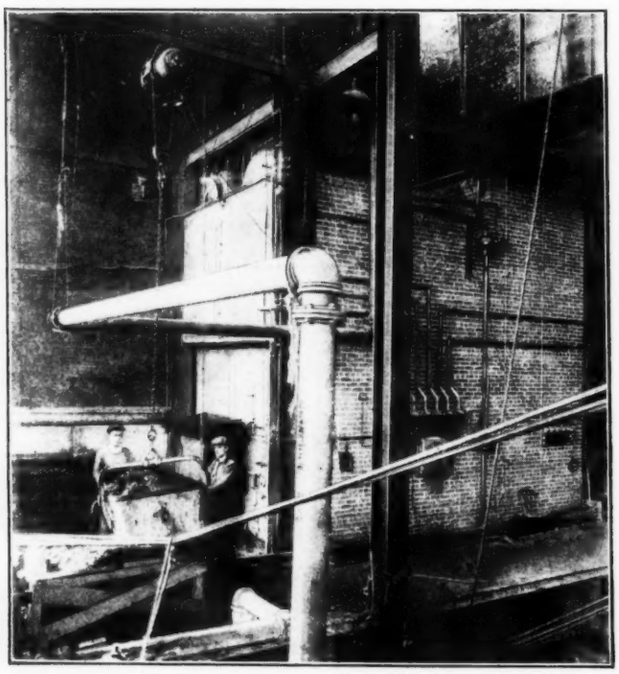


FIG. 9—FOR THE FIRST NEW BOILER TEMPORARY PROVISIONS WERE MADE FOR ELEVATING COAL FROM THE OLD BOILER ROOM FLOOR TO THE STOKER HOPPER BY A MONORAIL ELECTRIC HOIST

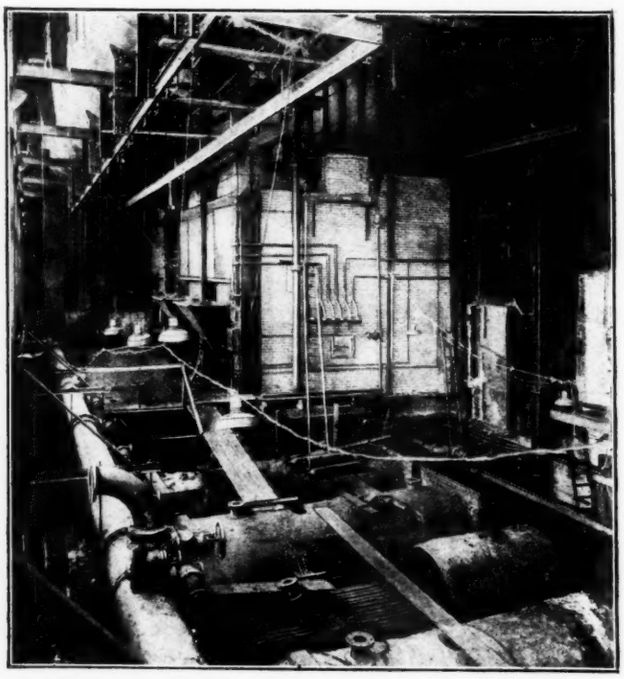


FIG. 10—THREE NEW BOILERS INSTALLED IN THE BACKGROUND; IN THE FOREGROUND OLD BOILERS BEING REMOVED BY CUTTING INTO PARTS WITH AN OXY-ACETYLENE TORCH

place to carry the two girders. On top of these girders short columns were erected to support the steel roof trusses.

After the completion of the floor for the first new boiler, the derrick was used to lower the boiler sections, which were then riveted together and the complete boiler erected in place. During this period the new roof was covered with forms for concrete, with a section omitted for entrance of the boiler and stoker. As soon as this heavy equipment was landed on the new boiler room floor, the concrete roof slab was poured.

The permanent smoke flue between the new boiler and the stack was then erected and blanked off at the connection points for the economizer and for the second and third new boilers. It was not necessary to have the economizers in operation for the first new boiler. Provision was made for elevating coal from the old firing aisle to the new boiler room floor by means of monorail type electric hoist. This coal elevating apparatus is shown in Fig. 9 and was satisfactory to care for coal supply to the first three new boilers. Temporarily, ashes from the first boiler were removed by hand, by pulling through the front doors of the furnace and taken to the basement by the coal-handling bucket.

Temporary steam connections from the new boiler into the old 16-in. steam header still in place above the new boiler room floor were made, and temporary boiler-feed piping was installed on this floor to care for the new boiler. It was necessary to make all connections into the existing steam and water piping either at night or on Sundays when those particular sections could be taken out of service.

The first new boiler, A, was placed in continuous operation with its temporary air, steam and water connections after a short tryout. The capacity of this boiler made it possible to shut down three of the old ones and the beginning of the second stage in the construction program.

The second step was begun by the removal of old boilers Nos. 7, 8 and 9, thus vacating the space below where the second and third new boilers were to be installed. These old boilers were cut into pieces with an oxyacetylene torch so that they might be removed without undue interference with the operations in the old-boiler firing aisle. Considerable portions of these old boilers and their brickwork were removed at night. In the space left vacant by their removal, the permanent center-span footings were installed and new floor beams erected for the second and third new boilers. As soon as the new floor was constructed, the two new boilers, B and C, were brought in over the tops of the six old ones still in service. To accomplish this without interfering with the operation of the old boilers, it was necessary to crib up from the division walls between them and construct a heavy-timber runway the full

length of this space. These two new boilers were shipped in sections and satisfactorily moved over the tops of the old ones and alongside of the old steam main without accident.

That portion of the permanent forced-draft air duct under the second and third new boilers was erected along with the first forced-draft fan. It was possible also to erect permanent ash hoppers under these boilers. Because of the temporary smoke flue supplying old boilers Nos. 10, 11 and 12, it was impossible, however, to erect the permanent steam main and feed pipes, consequently the two new boilers were also temporarily connected into the 16-in. steam main on top of the new boiler room floor.

While boilers B and C were being installed, the old boiler-feed pump and makeup pump failed, and it was necessary temporarily to install the new boiler-feed pump and a turbine-driven makeup pump.

That portion of the suspended steel coal bunker above boilers A, B, and C was erected, and all the coal handling apparatus above the new boiler room floor level during the course of construction for boilers B and C. Likewise, during the latter part of this period the economizer platforms had been completed and the economizer sections erected. Most of these sections were handled over the roof of the adjoining new turbine room and placed in their permanent positions at night, in order that there should be no interference with the operation of the induced-draft fans handling the smoke direct from boilers A, B and C.

As soon as boilers B and C had been tried out, they were placed in operation. The capacity that they developed made it possible to remove more old boilers. Therefore, boilers Nos. 10, 11 and 12, which were still in operation under boiler A, were removed. This cleared space for the installation of permanent ash hoppers, a permanent forced-draft duct and the connection for boiler A to this duct. A permanent steam main and the feed piping for boilers A, B and C were installed in the basement and temporarily connected to the present steam main distribution system and to the remaining portion of the boiler-feed piping system.

The space vacated by the removal of boilers Nos. 10, 11 and 12 made it further possible to construct the concrete pits in the basement floor for receiving the coal hopper and boot of the coal elevator. These pits were made of concrete, and since they were below the water level in the canal, it was necessary to make them waterproof. There was installed in the bottom of each pit a barrel with the heads removed, filled with pebbles. In it was located a piece of 6-in. pipe with a cap on the end and perforated holes in the sides. This formed a sump in the bottom of the pit from which water was pumped during the course of construction of the concrete walls and floors. As soon as the concrete was poured, pumping was stopped and the inside of the pit permitted to fill with water. When the concrete was set the water was pumped out, the top of the pipe covered with a cap and the pit left in a dry condition. This sump is always available for use in pumping dry the pit in case of necessary repair work for cracks or leakage in the concrete.

The completion of the second step in the construction program meant that approximately half of the new boiler plant area had been completed and that three of the five new boilers were in operation. The extent of construction work at this time is shown in Fig. 10.

The third step in the construction program was started by the removal of old boilers Nos. 1 to 6. These were likewise cut up by the oxyacetylene torch, either into halves or smaller pieces, and removed from the building. Fig. 10 shows these six old boilers during their removal. This also shows the relation between new boilers in the background on the new boiler room floor and the old boilers below. The old 16-in. steam main can be seen in place in the lower left-hand corner. This steam main was originally suspended from the old roof trusses, and during the course of construction, and while it was in operation, its suspension was changed from the old roof trusses to brackets attached to the new building columns. As fast as the new boiler room floor was constructed, this steam main was supported from it.

The fourth and fifth new boilers, D and E, were shipped completely erected and were brought into the building and to their permanent location through a temporary opening left in the north brick wall of the

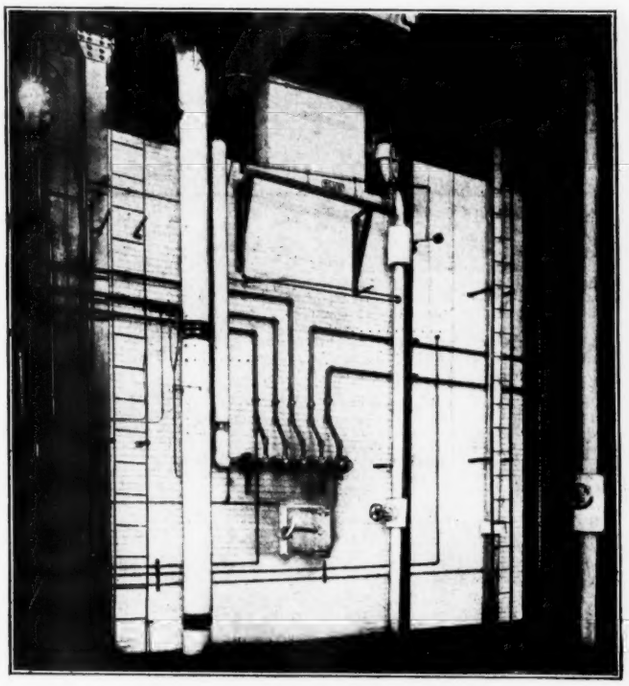


FIG. 11—NEW BOILER WITH STEAM PIPE LEADING TO HEADER IN BASEMENT—THE SOOT BLOWER HEADER IS ALSO SHOWN

new building. These boilers were set in place together with their auxiliary equipment and ash hoppers. When the space in the basement was vacated by the six old boilers, it was possible to start the installation of the boiler-feed pumps, the second makeup pump and the piping system for the new heater. As soon as the new boiler room floor for the fourth and fifth boilers was in place, the feed-water heater was installed and soon thereafter the new feed-water system placed in operation. This permitted the removal of the old feed-water heater which had been temporarily supported in the northeast corner of the boiler room. The permanent brick forced-air duct was extended to care for boilers D and E and the foundations made for receiving the second forced-draft fan, which was installed shortly after boilers D and E were placed in operation. There was left sufficient space between the fifth new boiler

and the end of the building for a future sixth boiler of the same size and with a similar setting to those installed.

The economizer and flue connections are so arranged that normal operation will pass the flue gases from the boilers through the economizers, induced-draft fans and into the stack. In case of repairs on economizers it will be possible to operate the boilers with flue gas passing directly through the induced-draft fans into the stack. Likewise, it is possible to operate a small amount of boiler capacity over Sunday on natural draft without the operation of the induced-draft fans.

After the new boiler room building was approximately completed, the adjacent turbo-generator room was remodeled to accommodate future power generating equipment. To do this the old roof was temporarily supported on the division walls of the five old boilers beneath and on the other side of the stack from the ground. The walls of this generator room were then torn out to approximate grade level and built up new to the new roof level. A new concrete and I-beam roof was constructed.

The five remaining old boilers were removed in the latter part of the year 1921, and the space occupied thereby, together with space on the other side of the chimney previously occupied by forced-draft fans, is now being utilized for the installation of two 1,000-kw., maximum rated, non-condensing, direct-current, geared turbo-generator units and one unit with same characteristics, except that it is a bleeder-type machine, with capacity for bleeding 20,000 lb. of steam per hour.

To accomplish the construction program, the engineers, Day & Zimmermann, Inc., placed a field organization on the job. It was the duty of this organization to arrange the construction program in such a way that it would interfere as little as possible with the operation of the old plant and the mill connected thereto. All construction work was carried out under the immediate direction of this organization. The erection of the boilers, the structural steel and the brickwork was let to contractors specializing in the various trades. But the main portion of the building and all of the details involved in the complicated construction work were cared for under the immediate supervision of the engineers.

## DATA ON MECHANICAL EQUIPMENT U. S. FINISHING COMPANY'S BOILER PLANT NORWICH, CONN.

### GENERAL

| | |
|---|---|
| Plant location | Norwich, Conn. |
| Boilers installed | 5 |
| Boilers installed, ultimate | 6 |
| Square feet of water-heating surface, each | 4,903 |
| Forced-draft fans, boiler feed and service pumps | Turbine-driven |
| All other auxiliaries | Motor-driven |
| Nature of load served | Bleaching, dyeing and finishing cotton goods |
| Length of boiler room inside | 117 ft. 3½ in. |
| Width of boiler room, inside | 47 ft. 10½ in. |
| Distance from basement to boiler-room operating floor | 14 ft. 0 in. |
| Ratio of boiler water heating surface to boiler house floor area (6 boilers) | 5.2 to 1 |
| Width of firing aisle | 18 ft. 6 in. |
| Width of passage behind boilers next to turbine room | 8 ft. 0 in. |
| Width of passages between boilers | 7 ft. 10½ in. |

### BOILERS

| | |
|---|---|
| Manufacturer | Heine Boiler Co. |
| Type | Horizontal water-tube |
| Steam drums, two | 36 in. x 21 ft. 8 in. |
| Plate | 13/32 in. thick |
| Tubes, 281; 3½ in. diameter, 18 ft. length, of special mild steel | |
| Heating surface | 4,903 sq.ft. |
| Grate area projected | 90 sq.ft. |
| Boiler-heating surface per sq.ft. of grate area | 54 sq.ft. |
| Working gage pressure, lb. per sq.in. | 200 |
| Superheat | None |
| Coal analysis: | |
| Fixed carbon | 68–62 per cent |
| Volatile hydrocarbons | 18–20 per cent |
| Sulphur | 1–2 per cent |
| Moisture | 5–6 per cent |
| Ash | 8–10 per cent |
| B.t.u. per lb. (dry fuel) | 13,750 |
| Height to center of steam drum above firing-aisle floor | 17 ft. 7 in. |
| Height to bottom of front header from firing-aisle floor | 10 ft. 0 in. |
| Combustion-furnace volume | 1,092 cu.ft. |
| Combustion furnace volume per sq.ft. of grate area | 12.13 cu.ft. |
| Boiler performance: | |

| Boiler Rating, Per Cent | Lb. of Coal Fired per Hour per Cu.Ft. of Fur. Vol. |
|---|---|
| 150 | 2.20 |
| 200 | 2.90 |

| | |
|---|---|
| Free area opening first pass | 22.7 sq.ft. |
| Free area opening second pass | 18.0 sq.ft. |
| Free area opening third pass | 10.9 sq.ft. |

### STOKERS

| | |
|---|---|
| Manufacture | Combustion Engineering Corp. |
| Type | E |
| Number of retorts | One |
| Stoker drive | Direct steam cylinders |

Stoker performance, based on coal 13,750 b.t.u.

| Boiler Rating Per Cent | Combined Boiler and Fur. Eff. Per Cent | Pounds Coal per Retort per Hour | Pounds Coal per Sq.Ft. Grate Area per Hour |
|---|---|---|---|
| 150 | 74 | 2,410 | 26.77 |
| 200 | 75 | 3,170 | 35.22 |

Four-hour continuous capacity ..... 250 per cent

### COAL BUNKER

| | |
|---|---|
| Contractor | Bethlehem Const. Co. |
| Type | Suspended steel |
| Number of days storage at normal operation | 4 |

### FORCED-DRAFT FANS

| | |
|---|---|
| Manufacturer | B. F. Sturtevant Co. |
| Number installed | 2 |
| Type | Double inlet, turbo-vane |
| Capacity | 80,000 cu.ft. per min. |
| Drive | Sturtevant turbine |
| Size | 150 hp. |

Forced-draft fan performance:

| Cu.Ft. per Min. | Static Pressure in Water, In. | Horsepower | R.p.m. |
|---|---|---|---|
| 65,000 | 6 | 100 | 940 |
| 80,000 | 6 | 125 | 1,000 |

| | |
|---|---|
| Fan capacity per sq.ft. of grate area (one fan for 5 boilers) | 180 cu.ft. per min. |
| Fan capacity per cu.ft. of furnace volume (one fan for 5 boilers) | 15 cu.ft. per min. |

### INDUCED-DRAFT FANS

| | |
|---|---|
| Manufacturer | B. F. Sturtevant Co. |
| Number installed | 2 |
| Type | Single inlet, multi-vane |
| Capacity | 82,000 cu.ft. per min. |
| Drive | Reliance Electric Co., motor |
| Size | 75 hp. |

Induced-draft fan performance:

| Gas, Lb. per Hr. | Gas Temp., Deg. F. | Cu.Ft. per Min. | Static Pressure | Speed, R.p.m. | Brake Hp |
|---|---|---|---|---|---|
| 154,000 | 375 | 54,000 | 2.5 | 282 | 27.0 |
| 154,000 | 575 | 67,000 | 1.6 | 253 | 22.0 |
| 220,000 | 425 | 82,000 | 3.5 | 350 | 61.0 |

### ECONOMIZERS

| | |
|---|---|
| Manufacturer | B. F. Sturtevant Co |
| Number units installed | 2 |
| Type | BM |
| Economizer performance based on operating boilers at 175 per cent of rating: | |
| Pounds of gas per hour | 154,000 |
| Pounds of water per hour | 79,200 |
| Temperature of gas | 550 deg. F. |
| Temperature of water | 150 deg. F. |
| Rise in water temperature | 80 deg. F. |
| Drop in gas temperature | 208 deg. F. |
| Final gas temperature | 342 deg. F. |
| Drop in draft through economizer | 0.75 in. |
| Total draft | 2.5 in. |
| Cu.ft. of gas per minute | 64,000 |
| Scraper drive | Westinghouse motors |
| Size | 3 and 5 hp. |

### MISCELLANEOUS EQUIPMENT

| | |
|---|---|
| Ash and coal handling equipment | R. H. Beaumont Co. |
| Soot blowers | Bayer Steam Soot Blower Co. |
| 2 Boiler-feed pumps, 450 gal. per min., 3-stage centrifugal | Dayton-Dowd Co. |
| 2 Boiler-feed turbines, 140 hp., direct connected | B. F. Sturtevant Co. |
| 2 Excess pressure regulators | Schade Valve Mfg. Co. |
| 1 Service pump, 500 gal. per min., single-stage centrifugal | DeLaval Steam Turbine Co. |
| 1 Service pump turbine, 40-hp. direct connected | DeLaval Steam Turbine Co. |
| 1 Feed-water heater, horizontal cylindrical | H. S. B. W.-Cochrane Corp. |
| 5 Boiler meters | Bailey Meter Co. |
| 5 Feed-water regulators, Copes | Northern Equipment Co. |
| Pipe covering, 85 per cent magnesia | Keasbey & Mattison Co. |
| 3 Draft gages, 2 in 1 | Precision Instrument Co. |
| Main steam valves | Chapman Valve Mfg. Co. |
| 1 Water-pressure regulating valve | Foster Engineering Co. |
| 5 Non-return automatic stop and check valves | Nelson Valve Co. |
| 1 Relief valve, exhaust steam line | G. M. Davis Regulator Co. |
| 1 Lever-balance valve, fan turbine regulation | Foster Engineering Co. |
| Steam traps, Squires | Evans Mill Supply Co. |
| Recording thermometers | Bristol Co. |
| Flue-gas equipment, Orsat | P. B. Huyette Co. |
| 5 Expansion joints, copper, single | E. B. Badger & Sons Co. |
| Fire brick | Harbison-Walker Refractories Co. |

Steam piping, high- and low-pressure, furnished by Walworth Manufacturing Co. and W. K. Mitchell Co., Philadelphia, Pa. Miscellaneous small valves furnished by Jenkins Brothers. Design and construction by Day & Zimmermann, Inc., Engineers, Philadelphia, New York, Chicago.

# Leveling An Engine on Its Foundations

By G. GROW

AN ENGINE is usually shipped on a flat car, although at times flat-bottom coal cars are called into service. If the latter, one end must be removed in order to get the engine off the car.

Various methods are followed by erecting engineers, the particular one used depending upon the plant location and other considerations. It is usually feasible to have the car set so that one end is accessible. A good

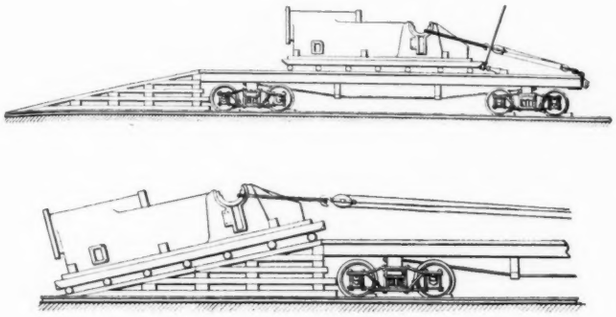


FIG. 1. REMOVING ENGINE FROM CAR

plan of unloading is to construct a runway leading from one end of the car to the ground, as in Fig. 1, at an angle of not over 20 deg.; a steeper incline causes the engine to become unmanageable.

The engine frame is lifted with ratchet or gear jacks and 6-in. maple rollers placed between the skids and car floor. Since the flooring is laid crosswise, 2 x 12 planking should be placed lengthwise of the car for the rollers to rest on. A 1½-in. rope-tackle block should next be fastened to the frame at some convenient place, such as around the bearing housings, and the second block chained to the railroad track or drawbar. The rollers support the frame with ease, and men can roll the frame to the end of the car with little trouble after getting it started by using a couple of jacks tilted against the skids at the back end. When the engine frame projects over the car floor enough to tip, the tackle block, already mentioned, should be tightened so that the front of the frame will come down on a roller without jar. By easing off on the tackle the engine will roll down the incline without a hitch, rollers being placed under the skids at intervals of about 3 ft. If maple rollers are not at hand, 3 or 4-in. pipe will do.

To move the engine onto the foundation, a runway of planking will make a good path for the rollers. Upon arrival at the foundation, the frame may be jacked up until the rollers can be moved onto the foundation or the runway inclined so that the rollers carry the engine onto the foundation.

As soon as the frame is in the proper position, the skids are removed. By using jacks at three of four points the frame may be lowered onto a set of wedges. These wedges should not exceed 1 in. in thickness at the heavy end, and should be 3 in. wide by about 8 in. long. A jack will seldom lower closer than 2 in. of its footing, and so it is often necessary to make a depression in the concrete into which the jack is set. The hole need not be over 2 in. deep if step, or, as they are usually called, Barrett, railroad jacks are used. These will usually raise 10 tons without danger of breaking.

For heavier frames, geared or hydraulic jacks should be used. These will lower to about 2 in. of the bottom. The geared type of jack is to be preferred, since a man can lift 20 tons with ease. Fig. 2 outlines the method of lowering the frame. Unless the frame weighs more than 30 tons, three jacks should be used, as this allows the leveling to be accomplished more easily than with four or more jacks.

The same procedure is followed with a vertical engine frame. In many of the vertical engines, the frame rests on a base which is by no means difficult to handle. This bed or subbase must be placed on the foundation and leveled before the engine frame proper is set.

Many oil engines are provided with adjusting screws along the lower edge of the base, as in Fig. 3. In leveling up, iron plates about 4 x 4 in. are set under these screws. It is well to level the plates, grout them in and allow the cement to harden before the screws are brought down against the plates. If soda is mixed with the cement the grouting will harden in 10 minutes. By manipulation of the screws the frame is easily made level.

If the engine has a horizontal frame it is often leveled by placing a spirit level across the planed tops of the bearing housing and lengthwise on the housing.

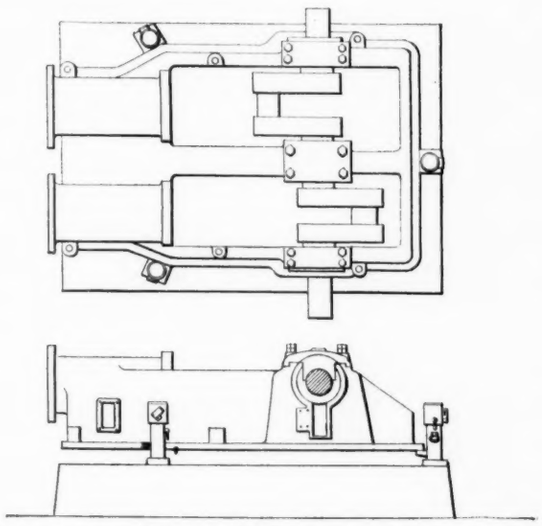


FIG. 2. LOWERING ENGINE ONTO ITS FOUNDATION

This will give a very close approximation of the true position. The erector must be careful that the engine shaft center line lies along the center line established at the time of putting in the foundation when posts with center tacks were set in to establish both the shaft and pulley center lines.

In all probability these posts are too low to allow a line to pass over the frame level with the top of the posts. Under these conditions center-line posts should be set in as close behind the first posts as possible without disturbing the latter. These posts should be high enough to permit the stretching of the wire above the

engine, clearing the frame by, say, 20 in. The approximate location is easily determined. A wire should now be stretched between the two posts in a level position. This wire should be in the same vertical plane as the wire originally set up. The dropping of a plumb bob will make this easy.

The leveling of this wire can be done with a spirit level. A good method of attaching the two wire ends for leveling is to place a smooth piece of tin over the top of one post so that the wire can be shifted sideways or vertically. On the other post erect two substantial strips, as in Fig. 3. To this end of the wire is attached a circular piece of tin, while to the other end is fastened a 30-lb. weight, which is hung over the first post. The weight gives a uniform tension to the wire and brings the wire back to its position if anything displaces it. The tin washer on the second end, by being placed behind the two strips, may be raised and lowered, or shifted slightly sidewise. This will allow the wire to be placed in the exact vertical plane. In addition the tin washer may be raised or lowered to bring the wire level. The leveling of the center-line wire is done by placing the spirit level along the wire. One cannot hold the tool level without some support, such as a frame of planking or blocks. The level may be brought up by wedging, the wire's position checked, and the tin disk tacked into place.

After this wire is put up, two wires should be laid at right angles to the lineshaft that is to be driven by the engine by the well-known 3-4-5 rule, and the distance from the driven shaft to the shaft center line wire measured for the purpose of checking the position. A steel tape should be used, as a linen tape is unsafe, stretching as much as 1 in. in 25 ft. The pulley center-line wire should be stretched if it has not already been established. Often the position of the pulley is marked on the shaft; if not, the position is indicated by the keyway.

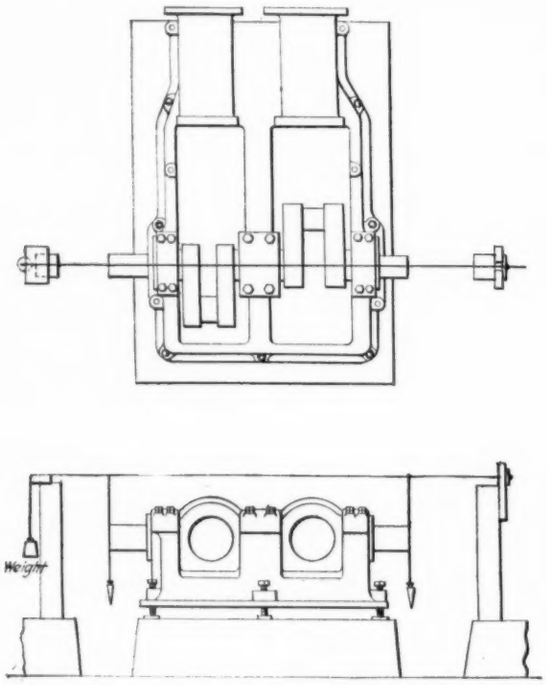



FIG. 3. METHOD OF FINDING CENTER LINE

Dropping a bob to the pulley center line will show how much the engine must be shifted sidewise to come into the correct position. To bring the engine shaft exactly under the shaft center line wire, erected as previously noted, putty should be hammered into the shaft-line centers and a small mark made in the exact centers. This is found by calipering the shaft. If plumb bobs are dropped from the center wire, the erector will be able to shift the engine the slight amount needed to bring these centers square with the bobs. Since the weight will always bring the wire back to its level position, the bobs may for convenience be hung from the wire. A good erecter, with the foundation bolts to guide him, should have the engine in a position that will require but little shifting. The next step is the leveling of the frame. Since the shaft is bedded in the bearings in its proper place, all that is necessary is to level the two ends of the shaft and then level the frame lengthwise. By measuring from the wire to the shaft with a pin gage the latter can be brought level with the wire. If the engine is of any size it is well to remember that the long wire will not be exactly level, having a small sag in it. Fig. 4 is a chart that appeared in *Power* some time ago showing the allowance that should be made for a 0.16 wire with different lengths between posts.

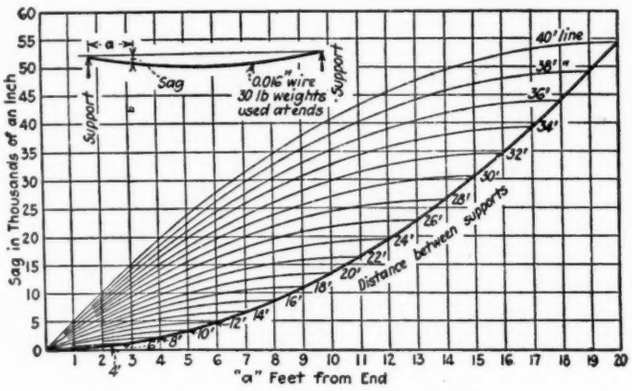



FIG. 4. SAG IN CENTER LINE

If an engineer's level is at hand, it may be set up at a point somewhere back of the engine. The instrument is then sighted at a rod placed vertically on one end of the engine shaft. A mark, cut by the hair line of the engineer's level, is made on the rod. Next the engineer's level is swung so that it will be in line with the mark when the rod is held on the opposite end of the shaft. One end of the frame must be raised or lowered until the mark again cuts the cross-hair. The leveling should be rechecked at least once. It is seldom, though, that such an instrument is available, although for engines over 500 hp. it should be used.

To align the frame lengthwise of the cylinder bore, it should be sufficient to level the bearing housing, although a safer procedure is to run a centerline through the cylinder.

A customary method, which, while apparently crude, is often followed successfully on small engines, is the leveling by means of a spirit level with a groove in one surface. This is placed on the engine shaft, and by the cross bubble brought up in the proper position. Longitudinal alignment of the shaft is then indicated by the second bubble.

The leveling of vertical engines calls first for the placing of the sub-base on the foundation, and its level-

ing. Engines as a rule have gage marks on the sub-base immediately below the shaft center line. With these gages no difficulty is experienced in leveling and setting the base in its place. In the absence of such gages, a board may be placed in the two outer bearings with a center line in each board. Still another method is to locate the center of the bearing and make a scratch on the face of the bearing at the bottom. This gives the center plane, and measurements can be taken from the bearing bottom rather than the shaft center. After the engine base or sub-base is properly leveled and set, the foundation bolts should be drawn up against the frame, but no great pressure should be used, for there is danger of distorting the frame.

Vertical engines of 200 hp. and less, especially high-speed units, are almost always shipped with cylinders

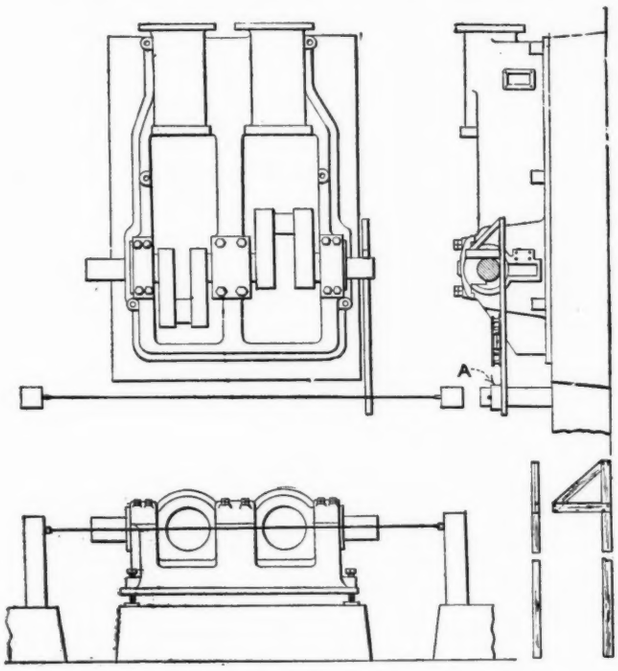



FIG. 5. A GOOD WAY TO LINE UP AN ENGINE

in place and the shaft in the bearings. It is costly to remove the cylinders for aligning purposes. An excellent method of leveling this type of engine, and one often used in horizontal units, is the running of a center line along one side of the foundation, parallel to the driven shaft. All that is required is to set the engine so that both ends of the shaft are equal distances from this line and that the shaft bottom at each end is the same distance below. A leveling bar as shown in Fig. 5 is made, preferably of hard lumber, being glued and screwed at the joints. This is placed under the shaft and in contact with it at the side and bottom, and is provided with the block *A* equal to one-half the shaft diameter. A spirit level set on the bar will show when the shaft is level with the wire, while a mark on the bar will allow the engine to be shifted until both ends of the shaft are equally distant from the wire. This is an excellent method, and has the advantage of removing the center line from the engine. If the shaft is not of the same diameter at the ends, accurate spacing blocks placed on the bar to equalize the discrepancy will do nicely. For engines of less than 300 hp., this leveling method is the most practical of all. It is not necessary to have the wire level with the desired shaft center line. All that is required is that the line be level and parallel to the future engine center line.

Before running the grouting, boards should be placed around the foundation, extending above the surface the desired depth of the grouting. A mixture of one part sand and one part cement should be thoroughly mixed with enough water to make it flow readily. This is poured in around the base and troweled into the center of the foundation. The space between the bolt and iron piping should also be filled. Each bolt-hole should be filled completely, and the ordinary laborer should be watched to prevent him from covering the top of the foundation before fully filling the holes.

Enough grouting should be poured in to fill the space up to the top of the boards already mentioned. As the cement sets, the boards may be removed and the grouting troweled down at a bevel. After this has set for several days, the foundation-bolt nuts should be drawn up tight and the iron wedges knocked loose, or, in case of screens, these should be backed off a little.

## Comparison of Synchronous-Motor Generators and Rotary Converters

In this comparison, motor-generator sets will be considered as driven by synchronous motors. This drive is generally used for motor generators, as they do not start under load and require no large starting torque. Also, a synchronous motor may operate at high power factor and permit of power-factor control. Synchronous-motor drive requires excitation for the motor field which may be had by the use of a direct-connected or belted exciter. Synchronous motors run at constant speed, and where motor generators are to operate in parallel, this drive insures an equal division of load.

In the past, the 60-cycle converter was considered somewhat less reliable than a motor generator; but it is now as reliable as the 25-cycle converter, and both compare favorably with the motor-generator set as to reliability. The insulation of a converter is less likely to failure than that of a motor generator, as the converter is necessarily a low-voltage machine, while the motor generator would usually be wound for full line voltage. A flash-over at the commutator is more likely to occur on a converter than on a motor-generator set, although under proper design this is seldom experienced.

An advantage of the motor-generator set is the independence of the two sides. A change of power factor does not change the direct-current voltage. On the other hand, a change in frequency will change the direct voltage; but in the case of a converter there is no change in direct voltage with a change in frequency. The two sides of a converter operating with a synchronous booster are nearly as independent as the two sides of a motor-generator set.

A converter has a decided advantage over the motor-generator of the same speed and capacity in being more efficient. The efficiency of a 25-cycle converter, including transformers, reactances, etc., is 6 to 8 per cent more than the efficiency of a motor-generator set without transformers; in the case of a 60-cycle converter the difference is from 3 to 6 per cent. A 60-cycle converter, together with its transformers and auxiliaries, requires less floor space than a corresponding motor-generator set.

# Softening Boiler-Feed Water with Zeolites*

## How the Zeolites Remove Hardness—Details of Operation—Data on a Typical Installation—Combination Lime-Zeolite Treatment for Water High in Temporary Hardness

THERE is not much connection between managing a boiler plant and running a farm, yet the modern science of agriculture has made a distinct contribution to that of boiler room operation.

Agricultural scientists have known for many years that the plant foods contained in fertilizers are retained better by some soils than by others. Then it was discovered that certain sand-like substances known as

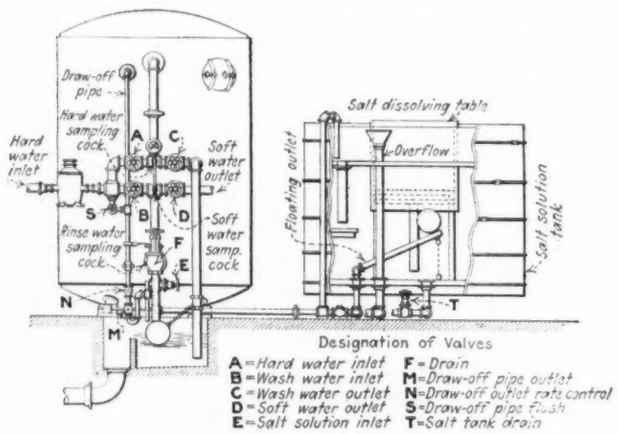



FIG. 1—ZEOLITE SOFTENER FOR A SMALL BOILER PLANT

"zeolites" were doing this storing, taking up the soluble salts of potassium and holding them in insoluble form until the plant was ready to use them.

At length, after years of study in this field, Dr. Robert Gans, a German chemist, classified the various zeolites in accordance with their properties and finally developed a zeolite that had certain desirable properties in a marked degree. This substance, which is made by subjecting felspar, kaolin, pearl ash and soda to fusing and other special treatment, contains the following chemical elements: Hydrogen, oxygen, aluminum, silicon and sodium. The actual formula for the substance is rather complex and of little interest to the average operating engineer. For practical purposes it is sufficient to think of this particular zeolite, which we will hereafter call simply "zeolite," as composed of only two substances, one of which is sodium and the other a complex combination known as the zeolite radical.

As commercially prepared for feed-water treatment, zeolite has an appearance somewhat like that of ordinary sand, but differs markedly in its properties. Water passed through this insoluble "sand" becomes completely soft without the addition of any chemical to produce the softness. The explanation is this: The hardness of water is caused in the main by compounds of calcium and magnesium. What is ordinarily called the temporary hardness consists of the bicarbonates of these elements. When feeding boilers with hard water, the greater part of these are thrown down as a scale by the mere process of heating the feed water up to the boiling point. The sulphates and chlorides of calcium and magnesium, which are the principal forms of the so-called "permanent hardness," still stay in solution at 212 deg. F. and are not precipitated until they reach the higher concentrations and temperatures found in the boiler. All these forms of hardness are removed by the zeolite, which pulls the calcium and magnesium out of these compounds and replaces them with sodium.

It should be noted that the zeolite never gives up sodium except where it can immediately replace it by the corresponding amount of calcium or magnesium. The result is that the action is automatic, adjusting itself exactly to the amount of hardness in the water, as long as the ultimate capacity of the apparatus is not exceeded. The substances left in the water by this exchange are sodium bicarbonate (ordinary cooking soda), sodium sulphate and sodium chloride (common salt) in the same amounts as the bicarbonates, suphates and chlorides originally present. These sodium compounds are entirely free from hard (scale-forming) properties. The only harm that they can do is that, when present in excessive amounts, they may cause priming. The remedy for this is to blow down at suitable intervals. As far as priming is concerned, the

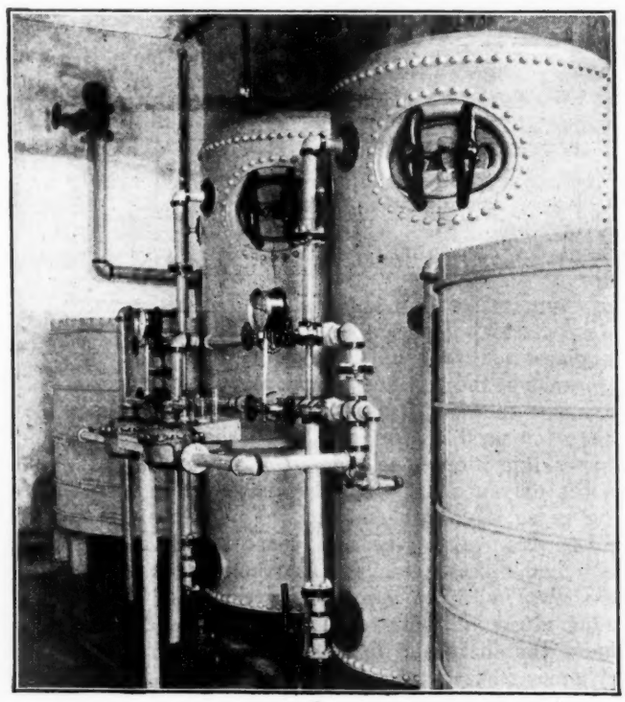


FIG. 2—DUPLEX INSTALLATION DESIGNED FOR CONTINUOUS OPERATION

This unit handles 27,600 gal. per 24-hour day of water having a hardness of 10 grains per gallon.

*This is the first of a series of articles on feed-water treatment. The second article, dealing with evaporators, will appear in the Sept. 19 issue.

treated water is equivalent to the untreated, since the total weight of dissolved solids remains the same. Exception to this statement must be made where the priming is due in part to oil, mud, etc., for in such cases it is customary to use a preliminary filter for the removal of these impurities before treating with zeolite, so that the treated water has less tendency to prime than the raw water.

The same transfer that softens the feed water replaces the sodium originally in the zeolite by the calcium or magnesium taken out of the water. As more and more of the sodium is replaced, the zeolite gradually becomes inactive. When, however, it loses its capacity to soften water, it is not necessary to throw it away. Exposure to a brine solution made with common salt (sodium chloride) is sufficient to restore it to its original condition, the salt putting the sodium back into the zeolite and taking out the calcium and magnesium.

The operation is as follows: To start the softener, open valves *A* and *D* to let water flow at a predetermined rate as indicated by the meter on the hard-water inlet line. All other valves are kept closed, the hard water passing through *A* and then up through the larger riser to the top of the softener. Entering the softener, it passes down through the zeolite bed, giving up all its hardness without precipitation or change in the amount of total solids. The softened water then passes out through the bottom connection and up through *D* to the soft-water storage tank (not shown).

The rate of flow of water is considerably below the maximum that will insure complete softening for the average hardness of the water handled. This margin of safety makes it unnecessary to make regular hardness tests of the raw or softened water during routine operation. Over-treatment is impossible, no matter how slowly the water is passed through the zeolite.

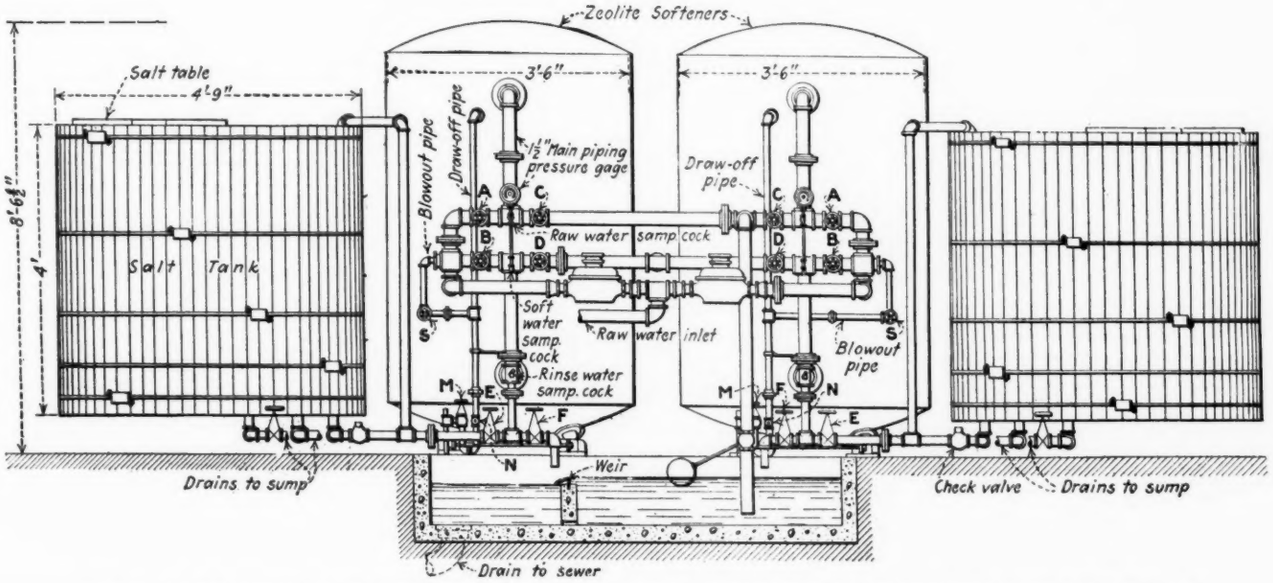



FIG. 3—ELEVATION OF PLANT SHOWN IN FIG. 2, WITH DIMENSIONS OF SOFTENERS AND SALT TANKS

The hardness is thus passed to the sewer as a clear solution with the used brine and subsequent rinsing water.

Both the transfer of the hardness into the zeolite and the later passing of this along from the zeolite to the salt solution, occur without any precipitation or formation of sludge. Where filters are used with this method of softening, their only purpose is to handle the suspended matter in the original water, or to take care of that produced by the addition of chemicals (in the case of combination lime and zeolite plants).

### Method of Operating a Typical Softener

The zeolite process for water purification is known by the trade name "Permutit." Fig. 1 shows such a system, of the intermittent type, designed to soften water for a small boiler plant or for industrial use. At the left is the softener, which is merely a tank nearly full of the sand-like zeolite and provided with piping, valves, meter, test cocks, etc., for regulating the alternate flow of the hard water and the regenerating brine through the bed of zeolite. The brine is prepared and stored in the wooden tank at the right, which holds enough salt solution for one regeneration of the zeolite.

Under-treatment, on the other hand, cannot occur if the prescribed rate and duration of flow are adhered to. The duration of flow, like the rate of flow, is fixed at a point considerably below the rated capacity of the softener for the given water supply. However, if considered desirable, the softened water may be tested at any time by drawing a 40-c.c. sample from the soft-water testing cock, and shaking it up with five drops of a special soap solution, or the A.P.H.A. standard soap test may be used. If a permanent lather results, it is proof that the water is soft.

When the specified number of gallons has passed the softener, all the valves are closed, after which valves *B* and *C* are opened. This raises and shakes up the zeolite bed by pushing water through it in the reverse direction. The wash water overflows through the main connection at the top, and passes down through valve *C* and a float-controlled discharge valve to a sump connected with the sewer. The float valve, acting in connection with a weir in the sump, maintains a constant flow of water, thus preventing the zeolite bed from washing out.

After the washing has been kept up at the prescribed rate for ten minutes or more until the wash water is clear, valves *B* and *C* are closed. Ten minutes is allowed

for the zeolite bed to settle, then valves *S* and *F* are opened, and valve *F* immediately closed again. Next the valve *C* is opened to remove air from the top of the softener so that it is full of water before regeneration is started. After that, valves *C* and *S* are closed in the order named. This manipulation of valves is to free the system of air to permit of siphoning the salt solution through the zeolite bed.

The bed is now ready for regeneration, the right-hand tank having previously been filled with a brine of common salt (about 10-per-cent solution). Starting with

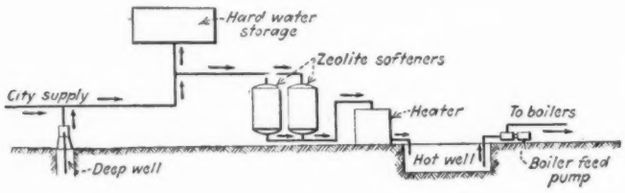



FIG. 4—TYPICAL FLOW CHART FOR A DUPLEX INSTALLATION

all valves of the softener and salt-solution tank closed, valves *E* and *M* are opened, permitting the brine to enter the softener at the bottom, pass up through the zeolite bed and siphon off at the top through the small draw-off pipe. The water seal at the bottom of this pipe prevents the breaking of the siphon, while cock *N* is permanently adjusted to pass the contents of the brine tank at the proper rate.

After the regeneration is complete, there remains a layer of exhausted brine above the zeolite bed. This is removed through valve *M* by closing valve *E* and opening valve *A*. The washing water is allowed to flow for about ten minutes. The brine remaining in the bed is reclaimed by closing valve *M* and opening valve *E* so that the salt solution is displaced down through the softener by water admitted through valve *A*. This solution is driven back into the brine tank for future use.

When the water from this plant is fed to a boiler, it is of zero hardness, so that boiler blowdown is determined only by the concentration that would cause priming. The maximum desirable concentration is usually between 0.5 to 1.5 deg. Baumé, depending on the design of and duty on the boiler. This can be controlled by using a standard hydrometer to test the contents of the blowdown water after it has cooled to 60 deg. F.

### Duplex Unit Permits of Continuous Operation

In larger boiler plants it is often desirable to install a twin (duplex) unit, with two softeners and two brine tanks. This permits of continuous operation by using one set of units for softening while the other is undergoing washing, regeneration and brine reclamation. Fig. 2 is a photograph of an installation of this type, while Fig. 3 is a drawing, in elevation, of the same installation. Since the piping connections and the methods of operation are substantially the same as for the plant already described, it will be unnecessary to go into details of construction and operation, but some operating data should be of interest.

This plant has a capacity of 27,600 gal. of 10-grain-per-gal. hard water in 24 hours, operating at the rate of 1,150 gal. per hour. The approximate price of the installation, delivered and erected, was $2,800. The only labor required for operation is the time of one man for a total of 2½ hours per 24-hour day. At 0.4 cent a pound the daily cost of salt is 66 cents. This amounts to a salt cost of 2.4 cents for softening 1,000 gal. of 10-grain-per-gal. hard water, or ¼ cent per 1,000 grains of hardness eliminated. For a larger plant the salt cost per 1,000 grains of hardness would be the same, but the labor and investment charges per unit of output would be less. Fig. 4 is a flow diagram for a boiler plant where hard well or city water is softened with a duplex zeolite plant.

With certain waters it is advisable to use a zeolite softener in combination with chemical pretreatment. The cold lime and soda treatment does not ordinarily reduce the hardness below 4 to 5 grains per gallon (as calcium carbonate), but it does reduce the total solids, provided the water contains temporary hardness. This is an advantage where the raw water contains a large amount of total solids, consisting largely of temporary hardness, because less blowdown is required if the total solids are reduced.

### Combination System Reduces Chemical Costs

The cost of lime required to treat temporary hardness is only about half that of the salt required to treat temporary hardness with zeolite. The opposite is true of permanent hardness, where the salt costs only about half as much as the soda. So where the water has equal parts of temporary and permanent hardness, the cost of the salt for the straight zeolite system is ordinarily about equal to the chemical cost of the straight lime and soda system. An excess of temporary hardness obviously favors the lime and soda process, while an excess of permanent hardness favors the zeolite, if the choice is only between these two systems. It is evident that the lowest chemical cost is obtained with a combination system that uses lime to reduce the temporary hardness and follows this with a zeolite treatment to take out the permanent hardness and the remainder of the temporary hardness. This also gives water of zero hardness, which cannot be obtained by the straight lime and soda process.

Assuming that dirt, oil, etc., are removed by special filtration, the boiler blowdown, as has already been explained, depends principally upon the total solids in the softened water. For that reason treatment by evaporators is usually recommended where the water is high in total solids consisting largely of sodium, as in the case with certain waters of the Southwest. In the case of sea water, evaporators are the only available method of treatment.

The manufacturers of the zeolite system state that the average annual net return from zeolite water-softening plants is in the neighborhood of 25 per cent, after allowing for labor and chemicals and subtracting 16 per cent of the investment for interest and depreciation. The savings comprise reduction in tube replacements, cost of scale removal, loss due to boilers out of service and fuel loss due to scale.

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The man who wastes fuel, wastes your money and mine as well as his own. He may be able to afford the loss but you and I cannot. He wastes our money because as a result of his waste we must pay more for our fuel and for all the commodities that we buy, including that commodity called "labor." The price of labor is fixed by the cost of living, for no man can work at a wage that will not enable him to live. Fuel is, and must continue to be, a large item in the cost of living.—*Jos. W. Hays*, Combustion Engineer.

# Safe Procedure to Follow in Opening Disconnector Switches

By RALPH BROWN*

THE importance of taking advantage of every reasonable safeguard in connection with disconnector switching cannot be too strongly emphasized, since the opening of a disconnector switch carrying current may cause a fatal injury, aside from considerable damage to equipment. It is just as important to exercise care in closing disconnectors, for under certain conditions synchronous apparatus may be paralleled out of phase, with possibly disastrous results, by closing disconnector switches. As an abbreviation, the word "disconnector" will be used interchangeably with the more common term, disconnector switch, in this article, and in directing switching operations it is always advisable to use the word disconnector.

In order to eliminate, in so far as possible, any misunderstanding where disconnector switching is involved, every disconnector should be given a standard designation, and this designation should be legibly lettered near the corresponding disconnector. The first step to be taken toward systematizing disconnector operation should be to prepare a three-wire diagram, carefully noting thereon all disconnector and oil switches and marking, near each disconnector, the proper designation. This diagram should be mounted near the switchboard, and all operators concerned with electrical operation should be required to memorize the name and location of each disconnector. The designation assigned to each disconnector should preferably be lettered in black, against a white background, as in Fig. 1, and while the designation so marked would refer to a group, the disconnector in each phase should be marked with a letter, such as *A, B, C.* Red stripes should be painted between each group of disconnectors.

**A DISCONNECTOR switch is such a minor part of the electrical equipment in the high-voltage alternating-current power plant that its real importance in safe plant operation is frequently not appreciated. There are numerous examples that bear testimony to the disastrous effects to human life and property caused by opening the switches on a circuit carrying load. Therefore, too much care cannot be exercised in opening these switches. In this article the author outlines practices that have proved to give a high degree of safety under a wide range of conditions. Of course, the human element must be contended with in all operations of this kind, and about the best that can be done in this regard is to try to ground the operators so thoroughly in the safe procedures that they will instinctively follow them not only under ordinary operation, but also in emergencies.**

The next step should be to place switch sticks in a number of convenient locations near the disconnecting switches, and the location of each switch stick should be noted on a suitable drawing; also by means of a sign at a point near where the stick is to be kept when not in use. All switch sticks for an approximately uniform voltage should be of equal dimensions and weight. A convenient method for supporting the switch sticks is to mount a flat iron plate, drilled and provided with a slot to receive the smaller diameter portion of the switch hook, over a 1-in. hole drilled an inch or so in the concrete wall. The stick is thus supported in a vertical position, which is usually the most convenient one. At least one switch stick for every four groups of three-phase disconnectors should be provided, and they should be kept in a dry location. It is desirable, as a safety feature, that the switch sticks be carefully wiped with a dry rag at frequent intervals, especially during damp weather. It is also well to test all switch sticks, periodically, to determine their insulating value.

The next step is to prepare complete and concise operating instructions concerning the methods to be followed in carrying out disconnector switching. As an outline in the preparation of these operating instructions, an example of disconnector switching, carried out in accordance with what is considered good practice, will be given. The three disconnectors on the bus side of a generator oil switch are to be opened, and the generator oil switch has, previously, been opened. Operator to Assistant: "Open No. 5 generator disconnectors, bus side." The assistant notes if the indicating lamps on No. 5 generator oil switch show that the oil switch is open, and if open, he turns the mimic disconnector to the half-open position (see *B* Fig. 3), while repeating, "Open No. 5 generator disconnectors, bus side." Since the assistant has repeated the order correctly, the operator so signifies by saying "Right."

The assistant promptly proceeds to No. 5 generator oil switch, obtains a switch stick and, standing opposite the center phase facing the oil-switch mechanism, notes if the oil switch is in the open position, as indicated at the control board.

If the oil switch is open, the assistant walks to a position facing the center-phase disconnector, and reads the sign, to be absolutely certain that he is facing No. 5 generator oil-switch bus-side disconnectors.

He now counts the disconnectors, one, two, three, between the two barriers painted with a red stripe, and removes the cell door over the first disconnector at his left. The disconnector is now opened about ¼ in., with the face turned to the side, to avoid possible injuries to the eyes, if an arc should develop. Since this disconnector is not carrying current, no arcing results when it is opened ¼ in., and the blade is carefully pulled to the full open position. Each of the remaining disconnectors are opened in the same manner as described, care being taken to open but three disconnectors, in the case of a three-phase circuit.

After replacing the disconnector cell doors, the assistant replaces the switch stick, returns to the control

*Great Western Power Co., Belden, Calif.

board and, turning No. 5 generator bus-side mimic disconnector to the full-open position, as at *C* Fig. 3, reports to the operator, "No. 5 generator bus-side disconnectors are open." The operator checks the position of the mimic disconnector, and repeats, "No 5 generator bus-side disconnectors are open." The assistant replies "Right."

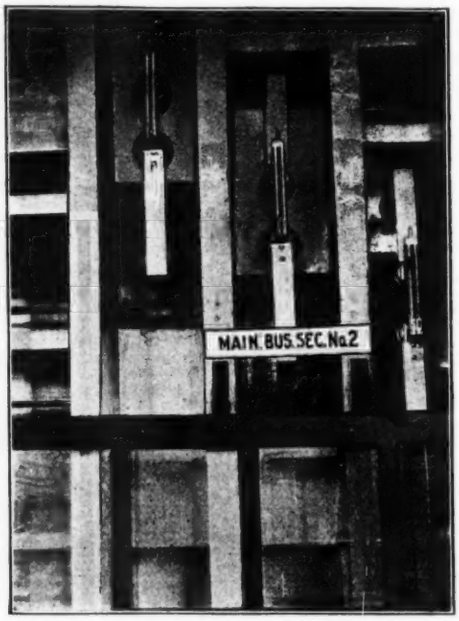



FIG. 1—GROUP OF THREE 11,000-VOLT DISCONNECTING SWITCHES

If the oil switch is to be grounded, the operator personally checks the position of the disconnectors.

In the foregoing example, it will be noted that each step toward opening the disconnectors is given practically a double check, thus not only tending to make this hazardous operation safe, but, which is just as important, largely eliminating the probability of the occurrence of mistakes.

It is usual to identify disconnectors by using the name of the oil switch which they isolate, but this method sometimes results in the forming of a name consisting of ten or twelve words. All operating instructions should be so written that they may be rigidly followed under all conditions of operation, and it is hardly to be expected that operating attendants will use cumbersome names when considerable switching is being done, during periods of trouble or at other times, unless too closely supervised. Hence, disconnectors should be identified by a name as brief as possible, or possibly by a number assigned to each individual group of three disconnectors.

To reduce the possibility of error, at least all important disconnectors should be shown on a mimic bus at the control board, and it is desirable that their open and closed positions be shown by indicating lamps.

Since most disconnectors are of the single-pole, separately operated type, one loaded disconnector is sometimes safely opened, the load being then carried by the other two. By first opening the disconnector a short distance, any indication of power current can be noted, and when only one phase has been opened, the disconnector can generally be safely returned to the closed position. It is highly important that a disconnector never be opened with one quick movement, for, should it be carrying load, a loss of property and life would probably ensue, due to the resulting arc.

Where the disconnector in each phase is covered by a separate cell door, a sign, long enough to span three doors, may be hung in such manner as to require its removal before any disconnector may be opened. This scheme makes it necessary for the operator to remove the sign giving the designation of the disconnectors, and when it is removed, only the three switches comprising one group of disconnectors are exposed, hence additional safeguards are introduced.

In at least one station each group of three disconnectors is covered by one door, which is kept locked, and the key is kept in a receptacle at the switchboard, near the oil-switch control switch. When disconnectors are to be operated, the operator must first remove the key near the control switch, and as this key unlocks but one door there is little likelihood of the wrong disconnectors being operated.

Where disconnectors are to be kept open, attention should always be directed to this fact, by standard caution or clearance signs, so that the operator can quickly eliminate such groups, when engaged in hurried or extensive disconnector operation.

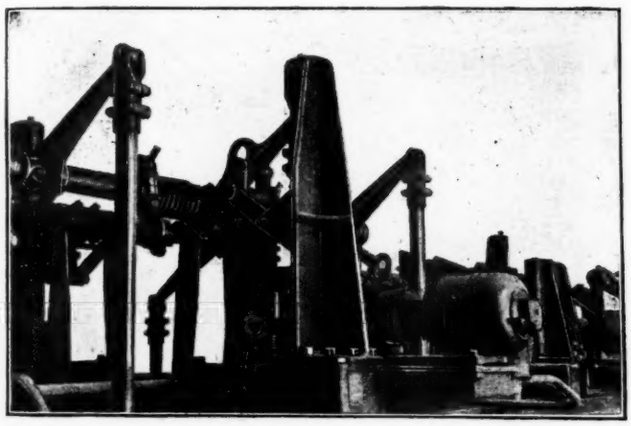


FIG. 2—OIL-SWITCH MECHANISM ON LEFT IN OPEN POSITION; MECHANISM ON RIGHT IN CLOSED POSITION

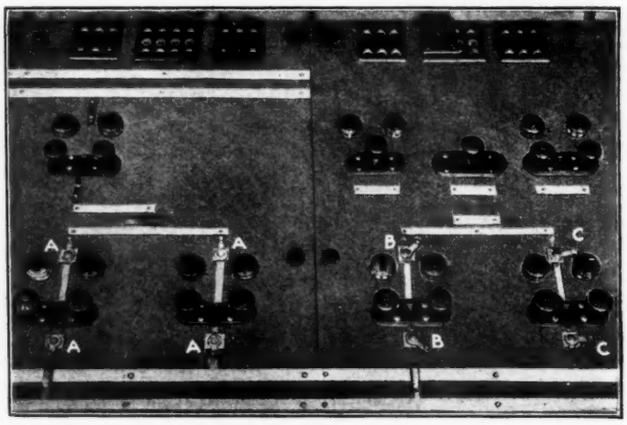



FIG. 3—MIMIC DISCONNECTING SWITCHES AT *A* CLOSED, PARTLY OPEN AT *B* AND ENTIRELY OPEN AT *C*

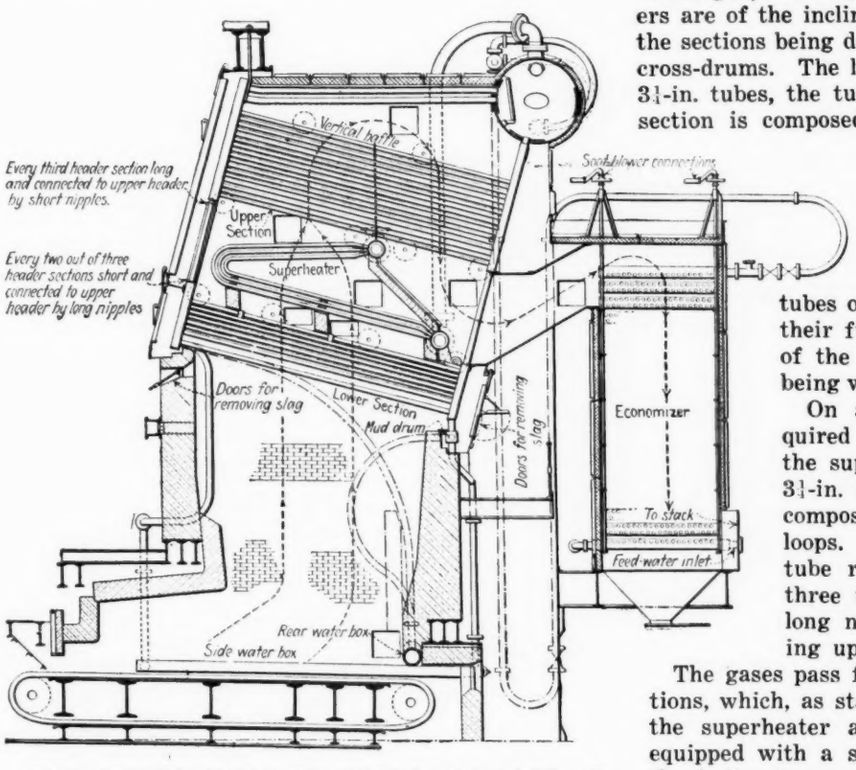
In some stations all orders pertaining to disconnector operation are issued in writing, which naturally tends to avoid mistakes. But if the members of the operating force have the proper training and supervision, the use of written orders and attendant delay is hardly warranted.

# High-Pressure Boilers for the Waukegan Power Station

**BOILERS, each having 14,086 sq. ft. of water-heating surface, of new design for 400 lb. pressure, which allows the use of metal thicknesses in the pressure parts no greater than in boilers designed for ordinary pressures.**

DURING the last few years there has been a distinct tendency in central-station engineering toward increasing the operating steam pressures. As a notable example of this tendency may be cited the new power station now being erected at Waugekan, Ill., about forty miles north of Chicago, for the Public Service Company of Northern Illinois, of which Samuel Insull is president.

The Waukegan station has been designed by Sargent & Lundy, Inc., engineers, and the steam pressure will be 400 lb. at the boilers—350 to 375 lb. at the turbines. There are a few small experimental or test plants running intermittently at such pressures, but this will be the first central station in this country to employ a boiler pressure in excess of 350 lb., and the boilers that will be used are a radical departure in the matter of design. The boilers are being built by the Babcock & Wilcox Co. and are entirely different from any previous type built by this company. They represent a design that has been developed by the engineers of that company, working in conjunction with the engineers of Sargent & Lundy over a period of two or three years, with a view to obtaining a boiler that will be suitable for considerably higher pressures.




SECTION THROUGH BOILER HAVING 14,086 SQ.FT. OF WATER-HEATING SURFACE, DESIGNED FOR 400-LB. PRESSURE

It has been recognized that in the design and construction of boilers for pressures in excess of 350 lb., the volume of individual elements of the boiler-pressure parts must be smaller than formerly used in order that the failure of any single element will not result in serious destruction. Further, small individual elements make possible the use of metal thicknesses for pressure parts of the high-pressure boiler, no greater than, if as great as, those for the larger elements ordinarily used in the construction of boilers designed for ordinary pressures. The difficulties that might arise from excessive thickness of metal exposed to heat and pressure are obviated.

The general features of design of the combined boiler, superheater and economizer unit as finally adopted for Waukegan, are indicated by the figure. These new boilers are of the inclined header design, 34 sections wide, the sections being double-decked and connected to 54-in. cross-drums. The lower sections are made up of eight 3½-in. tubes, the tubes being 15 ft. long. Each upper section is composed of 17 groups, each of two 2-in. tubes of the same length. The 3½-in. and the groups of 2-in. tubes are so arranged and spaced that there are access lanes between tubes horizontally and in two directions diagonally. The tubes of the lower sections are exposed for their full length to the direct radiant heat of the furnace, this portion of the boiler being without baffles.

On account of the high superheat required and also to avoid excessive size of the superheater, it is located between the 3½-in. tubes and the 2-in. tubes, and it is composed of three rows of 2-in. superheater loops. Provision is made for superheater tube removal by connecting two of each three upper and lower section headers by long nipples, the third of each three having upper and lower headers close-nippled.

The gases pass from the furnace over the lower sections, which, as stated, are without baffles, thence over the superheater and into the upper deck, which is equipped with a single baffle, making this portion of the boiler two-pass. The gases are taken from the boiler through the long nipples connecting the upper and lower rear headers, and led to the top of an economizer at the rear of the boiler setting.

With the fuel to be burned and at the capacities that will be developed, there will be some tendency toward the formation of slag on the tubes of the lower section. Provision is made for the removal of such slag from the forward part of the lower tubes through special doors below the uptake headers, and at the rear through special doors located opposite the nipples connecting the downtake headers to the mud drum, it being possible to use a "poke-rod" between these nipples.

The superheater chamber is such that there is ample room for access above, below and between superheater loops, and at the rear, below the second pass, to the superheater headers. This arrangement gives ample opportunity for periodical inspection and for thorough cleaning.

The economizer, placed at the rear of the boiler setting, is of the Babcock & Wilcox transverse-tube "Duratex" design and built for a working pressure of 450 lb. It is composed of 36 sections in height, each containing twenty 2-in. by 20-ft. tubes, which are connected by wrought-steel headers. Feed water enters the lower header at one end of the economizer and passes through a single row of tubes to the corresponding header on the other end. From this header the feed water passes through a second row of tubes to a second header on the feed inlet side of the economizer and in a similar manner through all sections in series from the bottom to the top. This design with the downward passage of gas and the upward passage of water through the economizer gives the counterflow of water and gas which is essential for the best heat absorption. The counterflow principle, together with the gas and water velocities employed, lead to best heat transfer rates and corresponding economizer efficiency.

Each boiler contains 14,086 sq.ft. of surface, the superheater 2,485 sq.ft., and the economizer 8,837 sq.ft. This boiler unit is designed for a normal output of 100,000 to 120,000 lb. of steam per hour and a maximum of 150,000 lb., the steam to be superheated to 700 deg. F. The boilers, which are set with a 21-ft. 7-in. furnace height, are fired under the uptake end and are equipped with Babcock & Wilcox forced-draft chain-grate stokers, each 21 ft. wide by 18 ft. 3 in. long, giving a grate surface of 383 sq.ft. and a ratio of grate to boiler heating surface of approximately 1:37. The blast chain grates are equipped with side wall and bridge wall wrought-steel water boxes connected to the circulation of the boiler.

It is expected that this design will be one of the most efficient boiler units yet developed, irrespective of pressure. Three of these complete units as described have been purchased for the Waukegan Station, and three units of the same section, though not so wide, for the Grand Tower Station of the Middle West Power Co., for which Sargent & Lundy are also the engineers.

# The Effect of Clearance on an Ammonia Compressor

IF AN ammonia compressor had no clearance, the ideal indicator diagram would be similar to Fig. 1. Here *CB* is the compression curve and *BA* the discharge line during which all the vapor in the compression is forced out through the discharge valve. At *A*, where the piston reaches the end of its stroke and reverses, the pressure drops immediately to *D*, the suction pressure, for there is no clearance between the piston and cylinder head, so there is no clearance vapor to re-expand. From *D* to *C* a charge of vapor at the suction pressure is drawn into the cylinder. The amount of this vapor, in cubic feet, is equal to the piston displacement, which is proportional to *BC*, the diagram length.

The indicated work of compression or the power required to lift the vapor from the suction to the discharge level and to force it out through the discharge valve, is proportional to the area of the indicator diagram.

In the diagram the lines *CB* and *BA* represent the pressure and volume conditions during the forward or working stroke of the piston, while *DC* represents the conditions during the suction stroke. The pressure when the piston is at any point in the working stroke as *X*, is *XX'* measured from the zero absolute pressure line *OV*. On the suction stroke, when the piston is at the point *X*, the pressure in the cylinder is *XX"*. The difference between these two pressures, or *X'X"* represents the difference between the pressures existing at a stated piston position during two distinct strokes. The pressure represented by *XX'* is the forward pressure and *XX"* the return pressure; the difference is commonly termed the effective pressure exerted by the piston at the point *X* in its stroke.

M.E.P. CONSTANTS FOR AMMONIA COMPRESSOR

| Pressure Ratio $\frac{P_B}{P_C}$ | Work Constant | Clearance Percentage | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 | 6.5 | 7 | 7.5 | 8 | 9 | 10 |
| 2 | 107.85 | 0.736 | ..... | 0.733 | 0.731 | 0.728 | 0.725 | 0.723 | 0.720 | 0.717 | 0.715 | 0.712 | 0.710 | 0.707 | 0.701 | 0.696 |
| 2.25 | 128.45 | 0.875 | ..... | 0.869 | 0.865 | 0.861 | 0.857 | 0.853 | 0.849 | 0.846 | 0.842 | 0.836 | 0.834 | 0.830 | 0.821 | 0.815 |
| 2.5 | 147.17 | 1.000 | ..... | 0.990 | 0.986 | 0.980 | 0.975 | 0.970 | 0.965 | 0.959 | 0.954 | 0.949 | 0.944 | 0.938 | 0.928 | 0.917 |
| 2.75 | 164.02 | 1.126 | ..... | 1.098 | 1.092 | 1.085 | 1.078 | 1.071 | 1.065 | 1.058 | 1.051 | 1.044 | 1.037 | 1.031 | 1.017 | 1.004 |
| 3 | 179.57 | 1.212 | ..... | 1.197 | 1.189 | 1.181 | 1.172 | 1.164 | 1.116 | 1.148 | 1.139 | 1.131 | 1.123 | 1.114 | 1.098 | 1.081 |
| 3.25 | 195.12 | 1.314 | ..... | 1.295 | 1.284 | 1.275 | 1.265 | 1.255 | 1.245 | 1.235 | 1.225 | 1.215 | 1.205 | 1.195 | 1.175 | 1.154 |
| 3.5 | 208.80 | 1.402 | ..... | 1.379 | 1.368 | 1.356 | 1.344 | 1.332 | 1.321 | 1.309 | 1.297 | 1.285 | 1.274 | 1.262 | 1.238 | 1.215 |
| 3.75 | 222.62 | 1.492 | ..... | 1.464 | 1.450 | 1.437 | 1.423 | 1.409 | 1.396 | 1.382 | 1.368 | 1.355 | 1.341 | 1.328 | 1.300 | 1.273 |
| 4 | 235.01 | 1.570 | ..... | 1.539 | 1.523 | 1.507 | 1.492 | 1.476 | 1.461 | 1.446 | 1.429 | 1.414 | 1.398 | 1.383 | 1.352 | 1.321 |
| 4.25 | 247.39 | 1.649 | ..... | 1.612 | 1.595 | 1.577 | 1.600 | 1.542 | 1.525 | 1.507 | 1.489 | 1.472 | 1.454 | 1.437 | 1.402 | 1.366 |
| 4.5 | 259.28 | 1.721 | ..... | 1.681 | 1.661 | 1.642 | 1.622 | 1.602 | 1.582 | 1.562 | 1.542 | 1.523 | 1.503 | 1.483 | 1.444 | 1.404 |
| 4.75 | 270.00 | 1.789 | ..... | 1.744 | 1.723 | 1.701 | 1.679 | 1.658 | 1.636 | 1.614 | 1.592 | 1.571 | 1.549 | 1.527 | 1.484 | 1.440 |
| 5 | 280.51 | 1.853 | ..... | 1.804 | 1.781 | 1.757 | 1.733 | 1.709 | 1.685 | 1.661 | 1.637 | 1.614 | 1.589 | 1.566 | 1.518 | 1.470 |
| 5.25 | 291.17 | 1.917 | ..... | 1.865 | 1.834 | 1.813 | 1.786 | 1.761 | 1.734 | 1.708 | 1.682 | 1.656 | 1.630 | 1.604 | 1.551 | 1.499 |
| 5.5 | 302.40 | 1.989 | ..... | 1.929 | 1.900 | 1.872 | 1.843 | 1.815 | 1.786 | 1.758 | 1.729 | 1.701 | 1.672 | 1.644 | 1.587 | 1.529 |
| 6 | 319.25 | 2.085 | 2.052 | 2.019 | 1.986 | 1.953 | 1.920 | 1.887 | 1.854 | 1.821 | 1.788 | 1.755 | 1.723 | 1.689 | 1.664 | 1.557 |
| 7 | 352.94 | 2.281 | 2.238 | 2.196 | 2.153 | 2.110 | 2.068 | 2.025 | 1.983 | 1.940 | 1.898 | 1.855 | 1.813 | 1.770 | 1.685 | 1.599 |
| 8 | 384.77 | 2.461 | 2.408 | 2.355 | 2.302 | 2.249 | 2.196 | 2.143 | 2.091 | 2.038 | 1.956 | 1.932 | 1.879 | 1.826 | 1.694 | 1.615 |
| 9 | 412.13 | 2.608 | 2.545 | 2.482 | 2.418 | 2.355 | 2.291 | 2.228 | 2.165 | 2.101 | 2.038 | 1.974 | 1.911 | 1.848 | 1.721 | 1.594 |
| 10 | 437.76 | 2.742 | 2.668 | 2.594 | 2.520 | 2.446 | 2.371 | 2.297 | 2.223 | 2.148 | 2.074 | 1.999 | 1.925 | 1.851 | 1.702 | 1.553 |
| 11 | 461.37 | 2.862 | 2.777 | 2.691 | 2.605 | 2.519 | 2.434 | 2.349 | 2.122 | 2.178 | 2.092 | 2.007 | 1.921 | 1.836 | 1.665 | 1.494 |
| 12 | 483.84 | 2.972 | 2.875 | 2.778 | 2.681 | 2.584 | 2.487 | 2.389 | 2.293 | 2.196 | 2.099 | 2.002 | 1.905 | 1.808 | 1.614 | 1.419 |
| 13 | 503.57 | 3.063 | 2.954 | 2.846 | 2.737 | 2.629 | 2.520 | 2.412 | 2.303 | 2.195 | 2.086 | 1.978 | 1.869 | 1.760 | 1.544 | 1.326 |
| 14 | 523.73 | 3.154 | 3.034 | 2.914 | 2.793 | 2.672 | 2.552 | 2.431 | 2.311 | 2.190 | 2.070 | 1.949 | 1.828 | 1.708 | 1.467 | 1.226 |
| 15 | 541.15 | 3.229 | 3.089 | 2.964 | 2.832 | 2.699 | 2.568 | 2.435 | 2.303 | 2.170 | 2.038 | 1.906 | 1.736 | 1.641 | 1.377 | 1.112 |
| 16 | 559.29 | 3.305 | 3.160 | 3.015 | 2.871 | 2.726 | 2.581 | 2.436 | 2.292 | 2.147 | 2.002 | 1.857 | 1.712 | 1.568 | 1.278 | 0.950 |

The diagram area is proportional to the work done on the vapor, and if this area be divided by the length $BC$, the result is proportional to the average or mean pressure exerted by the piston, or as it is more commonly termed, the mean effective pressure. In other words, the diagram area is equal to a rectangle, Fig. 2, whose base is $DC$ and whose height $DA'$ is equal to the average height of the area $ABCD$, or $DA'$ is proportional to the mean effective pressure of the indicated diagram.

### Work of Ammonia Compression

Ammonia, unlike steam, behaves at ordinary temperatures and pressures as a gas, and for this reason the compression curve $CB$ does not follow the equation $PV$ = constant, but the formula for a gas, $PV^n$ = constant, where $n$ for ammonia has been found to be 1.3. For this reason the equation for the mean effective pressure in a steam engine (see *Power*, April 25, 1922) does not apply in the case of ammonia.

The work required to compress the ammonia vapor from a pressure of $P_C$ to a higher pressure $P_B$ and force it out of the cylinder is

$$Work = P_C V_C \left[\frac{n}{n-1}\right]\left[\left(\frac{P_B}{P_C}\right)^{\frac{n-1}{n}} - 1\right]$$

The mean effective pressure, or the average net pressure exerted by the piston, is the work divided by the piston stroke $V_C$, or

$$m.e.p. = \left(\frac{n}{n-1}\right) P_C \left[\left(\frac{P_B}{P_C}\right)^{\frac{n-1}{n}} - 1\right]$$

which, substituting the value of $n$, which is 1.3 for ammonia, becomes

$$m.e.p. = 4.33\ P_C \left[\left(\frac{P_B}{P_C}\right)^{.231} - 1\right]$$

The theoretical m.e.p. of a compression without clearance and with any suction pressure and any discharge pressure may be found by using this formula.

The majority of compressors have some clearance; even in a single-acting vertical ammonia compressor having a false head, a small amount of clearance is provided to allow for the expansion of the parts when warmed up. So as a broad statement it may be said

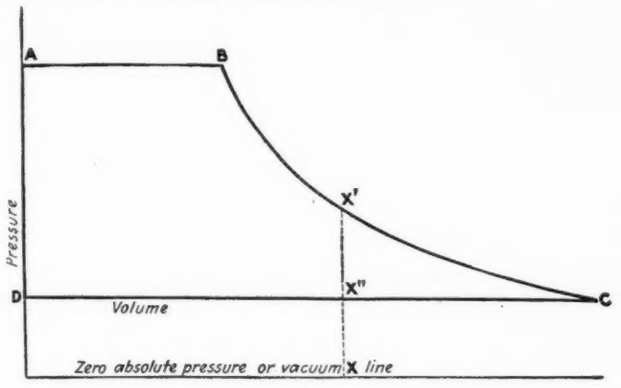



FIG. 1—IDEAL NO-CLEARANCE DIAGRAM

that clearance is necessary. In high-speed compressors the clearances run up to a considerable percentage of the cylinder volume, as is indicated in Fig. 3. In this diagram at the end of the piston stroke at $A$ there is a volume of gas trapped in the clearance space proportional to the distance $AA'$ or $V_A$. When the piston moves on the suction stroke, this clearance gas reexpands along the curve $AD$. At $D$ the valve opens and ammonia gas is admitted into the cylinder from $D$ to $C$. The volume of the clearance gas at $D$ is proportional to the distance $D'D$ or $V_D$. The entire cylinder volume at the end of the suction stroke is $CD'$ or $V_C$. The suction vapor drawn into the cylinder is, then, $D'C - D'D$, or $V_C - V_D$. The volume of suction vapor taken into the cylinder in proportion to the total piston stroke is called the volumetric efficiency, $E_V$, of the compressor. This is $\frac{V_C - V_D}{\text{stroke volume}}$, or $\frac{V_C - V_D}{V_S}$ when $V_S = V_C - V_A$.

Now $V_C = V_S + V_A$ and by the relation $P_A V_A^n = P_D V_D^n$ we find $V_D = V_A \left(\frac{P_A}{P_D}\right)^{\frac{1}{n}}$. By substituting these values, the volumetric efficiency becomes $E_V = 1 - C\left[\left(\frac{P_A}{P_D}\right)^{\frac{1}{n}} - 1\right]$ when $C$ equals the per cent clearance, or $\frac{V_A}{V_S}$

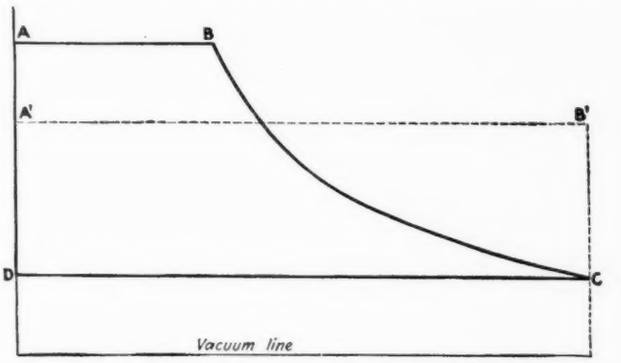



FIG. 2—RECTANGLE EQUAL TO THE DIAGRAM AREA

Inspection shows that the volumetric efficiency decreases as the clearance increases. Likewise, as the ratio of the discharge to the suction pressure, $\frac{P_B}{P_C}$ or $\frac{P_A}{P_D}$, increases, the efficiency decreases. This means that in a compressor of a given piston displacement the amount of suction gas handled by the compressor per stroke decreases with an increase in pressure ratio or with an increase in clearance.

### Mean Effective Pressure

In finding the mean effective pressure of a compressor, the formula given at the beginning of this discussion for a cylinder without clearance will not apply. It will be noticed that the indicator diagram of a clearance compressor is equal to the no-clearance diagram $CBA'D'$ less the work area of the re-expansion diagram $A'D'DA$.

The work of the no-clearance compression is $\left(\frac{n}{n-1}\right) P_C V_C \left[\left(\frac{P_B}{P_C}\right)^{.231} - 1\right]$ and the work of the re-expansion diagram $A'D'DA$ is $\left(\frac{n}{n-1}\right) P_D V_D \left[\left(\frac{P_A}{P_D}\right)^{.231} - 1\right]$. Since $P_A = P_B$ and $P_D = P_C$, the re-expansion work becomes $\left(\frac{n}{n-1}\right) P_C V_D \left[\left(\frac{P_B}{P_C}\right)^{.231} - 1\right]$. The work represented by the diagram $ABCD$ is the difference of these two, or $P_C [V_C - V_D] \frac{n}{n-1} \left[\left(\frac{P_B}{P_C}\right)^{.231} - 1\right]$. The

mean effective pressure is this work divided by the stroke volume $V_S$. But $\frac{V_C - V_D}{V_S}$ is the volumetric efficiency $1 - C\left[\left(\frac{P_B}{P_C}\right)^{\frac{1}{n}} - 1\right]$, so that the m.e.p. of a compressor with clearance becomes $= \frac{n}{n-1}$

$$P_C\left[\left(\frac{P_B}{P_C}\right)^{.29} - 1\right]\left[1 - C\left[\left(\frac{P_B}{P_C}\right)^{.71} - 1\right]\right]$$

In the table are given sets of constants for various pressure ratios, $\frac{P_B}{P_C}$, and for various clearances. By multiplying the correct constant in the table by the suction pressure carried, the m.e.p. may be obtained without the computation required by the formula. The pressures are absolute; that is, gage plus 14.7 lb.

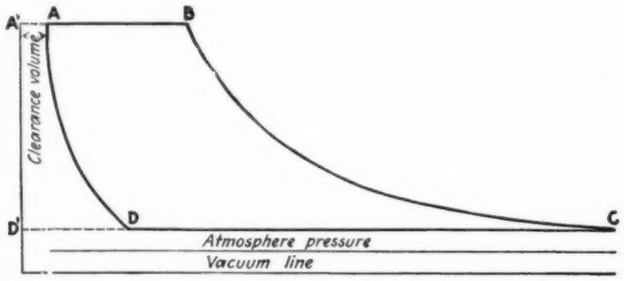



FIG. 3—DIAGRAM FROM COMPRESSOR WITH CLEARANCE

An inspection of the table will reveal that with any stated suction pressure, increasing the clearance percentage reduces the mean effective pressure. One surprising fact brought out is that with any suction pressure and any clearance ratio the mean effective pressure increases with an increase in the discharge pressure until a maximum value of the m.e.p. is reached, whereupon increasing the pressure ratio decreases the m.e.p.

## Horsepower per Cubic Foot of Vapor

The theoretical horsepower per cubic foot of suction gas handled may be obtained from the equation for the work done per stroke. The work in foot-pounds required per cubic foot of suction gas was given as the work constants. These work constants for various pressure ratios when multiplied by the suction pressure in pounds per square inch absolute give in foot-pounds the work of the compressor per cubic foot of suction. It will be noticed that the work per cubic foot of gas increases with an increase of the pressure ratio. An interesting point is brought out in Fig. 4, showing the foot-pounds of work required to compress a cubic foot of ammonia vapor. There is for any two suction pressures a discharge pressure at which the work per cubic foot of suction vapor is identical.

The table is of advantage in arriving at the size of motor required to drive a compressor; the value given should be increased by 15 to 25 per cent to care for the frictional resistance and other losses. If a motor is of the correct size to handle the compressor having a definite suction and discharge pressure, with a reduction in the suction pressure or an increase in discharge pressure, the question arises will the motor carry the load?

For example, assume the compressor having 3 per cent clearance is operating with a suction pressure of 15 lb. gage, or 30 lb. absolute, and a head pressure of 165 lb. gage, or 180 lb. absolute. The pressure ratio is $\frac{180}{30} = 6$ and m.e.p. will be $30 \times 1.539 = 46.17$ lb. If now the suction pressure is reduced to 15 lb. absolute, or zero gage, the ratio becomes $\frac{180}{15} = 12$ and the m.e.p. will be $15 \times 2.778 = 41.65$ lb. The motor is then large enough for the new condition. On the other hand, with a 20 lb. absolute (+5 lb. gage) suction pressure the pressure ratio would be 9. The m.e.p. will from the table be $20 \times 2.48 = 49.6$ lb. With the motor loaded up to its limit when the suction pressure is 30 lb. absolute it will be too small if the suction pressure is reduced to 20 lb. absolute.

## Advantage of Variable Clearance

Still another use may be made of the table. If the refrigerating plant is purchasing electric power and the contract has a maximum demand rate clause, a rise in the pressure ratio may increase the maximum demand rate. If the compressor is fitted with some method of altering the clearance, the maximum demand may be kept at any desired value. For example, assume that the compressor mentioned must operate with a suction pressure of 20 lb. and the high temperature of the cooling water required 200 lb. absolute discharge pressure. The m.e.p. with the new ratio of 10 to 1 will be $2.59 \times 20 = 51.8$ lb., while the m.e.p. with 30 lb. suction and 180 lb. discharge has been found to be 46.1 lb. To keep the m.e.p. down to 46.1 lb. will require a constant of $46.1 \div 20 = 2.305$. The table shows this to require a clearance of practically 5 per cent.

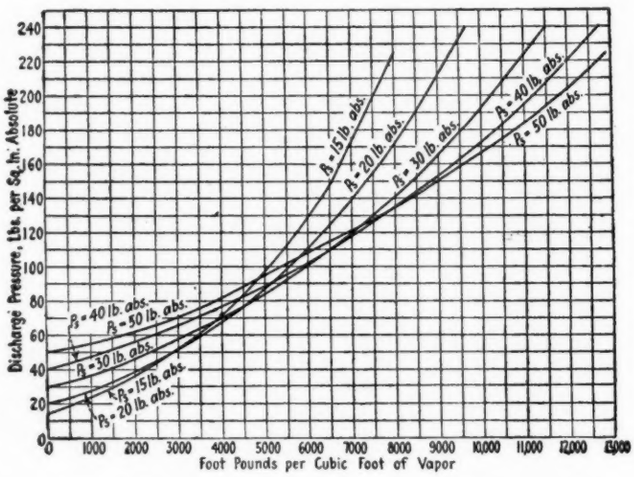

Discharge Pressure, Lbs. per Sq. In. Absolute
Foot Pounds per Cubic Foot of Vapor
$P_S$ = 15 lb. abs.
$P_S$ = 20 lb. abs.
$P_S$ = 30 lb. abs.
$P_S$ = 40 lb. abs.
$P_S$ = 50 lb. abs.

FIG. 4—WORK PER CUBIC FOOT OF SECTION VAPOR

By adjusting clearance pockets to give 5 per cent clearance, the maximum demand rate will be held to its normal value, although the volumetric efficiency and cubic feet of suction vapor handled will decrease.

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Theoretically, the amount of active material required to produce one ampere-hour is either 0.135 oz. of sponge lead on the negative plate, or 0.156 oz. of lead peroxide on the positive plate, and it must be completely converted to lead sulphate. In practice from four to six times this amount is required, because only a small portion of the active material is allowed to change to lead sulphate on discharge; otherwise it would be impossible to recharge the cell.

# How to Select Steam-Cylinder Oil

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

AFTER all the operating conditions affecting a particular steam engine are thoroughly understood, it then becomes necessary to consider their effect on the various physical and chemical properties of lubricating oils in order to select a cylinder oil that will satisfactorily meet the requirements. A brief summary of these facts follows:

A lubricating film is most easily formed when the cylinder oil is completely atomized.

Complete atomization depends upon steam temperature and moisture content, upon steam velocities and mechanical atomizing appliances, upon viscosity and surface tension, and upon the time allowed before the oil reaches the cylinder.

High temperatures improve the atomization of the oil; low temperatures retard it and make it necessary to use quick-atomizing oils.

Mechanical atomizers and a suitable arrangement of the feed lines can be made to improve the atomization of an oil. They are sometimes quite necessary for the proper atomization of viscous oils.

Low-viscosity oils are more readily atomized than high-viscosity oils.

Oils of low surface tension are more completely atomized than those of high surface tension.

Introducing the feed of oil some distance from the cylinder allows more time for proper atomization of the oil before it reaches the cylinder wall.

Better results can be secured by feeding the oil into the steam line six to eight feet above the throttle than just below the throttle or directly into the steam chest.

When the point of oil introduction is close to the cylinder, quick atomizing oils are required.

Filtered steam-cylinder oils atomize more quickly than those that have not been filtered.

Moisture in the steam improves the atomization of the oil.

Compounding in the oil improves its ability to atomize.

High steam velocities improve the atomization of the oil, although they allow a shorter time for complete atomization before the oil reaches the cylinder.

The maintenance of the lubricating film on the cylinder wall is affected by the steam temperature, velocity and content of moisture, by the adhesion, viscosity and volatility of the oil, by the speed, pressure and design of piston and ring, and by the character of the cylinder metal.

High steam temperatures tend to evaporate the oil off the cylinder wall and necessitate the use of more oil or a less-volatile oil.

High steam temperatures reduce the viscosity of the oil, and it is more easily scraped off the cylinder wall by the piston and rings.

High steam temperatures reduce the adhesion of the oil, and it is more susceptible to the scouring action of moisture and steam velocity.

Moisture in the steam is detrimental to the oil film because it tends to wash it away.

The adhesion of the oil under conditions of moisture can be improved by the addition of compounding to the oil.

Non-filtered steam-refined cylinder oils withstand moisture conditions better than filtered cylinder oils.

High-viscosity oils withstand the rubbing action of the piston better than low-viscosity oils.

High-viscosity oils are less susceptible to scouring by steam and moisture.

Oils of low volatility will remain on the cylinder wall for a greater length of time after the engine is shut down than those of high volatility—a great advantage when the engine is operating at irregular intervals.

Oils of low volatility are more economical in forming a film than those of high volatility.

High piston speed rubs the oil film off rapidly and requires more oil to maintain the film.

High piston-ring pressures tend to scrape the oil away.

Filtered cylinder oils separate from exhaust steam more readily than non-filtered oils.

Straight mineral oils can be removed from exhaust steam more completely than compounded oils, an advantage where the exhaust steam is used for manufacturing purposes where the oil would damage the goods.

Steam-cylinder oils are always made from paraffin-base crudes, the quality of the oil depending upon the care used in refining. The viscosity and low volatility are secured by steam distillation, a process which removes the hydrocarbons of low boiling points almost completely without its being necessary to raise the temperature so high as to cause decomposition of the oil.

Steam-refined cylinder oils are made in a number of grades according to viscosity and according to volatility, those of the lowest volatility being more expensive than those of higher volatility. This is one very good reason why the cheapest possible oils should not be used where conditions are likely to cause them to evaporate rapidly. Viscosities range from 90 to 200 Saybolt at 210 deg. F.

Filtered cylinder oils are made from the same stock as the steam-refined cylinder oils, but through having been filtered, the heaviest hydrocarbons and the more adhesive ones have been removed. This makes the oil translucent instead of opaque as are the non-filtered steam-refined oils.

Because of the many variables in the individual installations it is not possible to make a single recommendation of one brand of cylinder oil to meet all conditions. The peculiarities of each installation should be studied carefully, and the cylinder oil selected which will most satisfactorily take care of them. This requires a thorough understanding of the properties of the oils and of the effect of the mechanical and steam conditions upon them.

Q. What kind of oil should be used for a 1,000-hp. cross-compound Corliss steam engine running at 70 r.p.m., steam pressure 150 lb.; no superheat, good boiler water, little moisture? Oil feed is 8 ft. above the throttle.

A. A steam refined, non-filtered steam cylinder oil of 130-140 seconds viscosity Saybolt at 21 deg. F., containing 5-6 per cent compounding will prove best.

Q. If the same engine were to operate on 100 deg. superheat, what change should be made in the oil?

A. The same oil as recommended above could be used, but a little better economy could be obtained by the use of the same kind of an oil but of higher viscosity, about 150-160 seconds Saybolt at 210 deg. F.

Q. What sort of cylinder oil is best adapted for a 10x12 piston-valve engine at 250 r.p.m., using 100 lb. steam pressure, running non-condensing, with fairly dry steam. Oil feed is direct to throttle.

A. A filtered cylinder oil of 110-115 seconds Saybolt viscosity should give satisfactory results.

## Another Impulse Turbine Enters the Field

The Standard Turbine Corporation, Wellsville, N. Y., is now building impulse turbines up to 600-hp. whose design involves close standardization, requiring a minimum of labor but ample material.

The casing of the turbine, Fig. 1, consists of a steam end and an exhaust end having bolted between them a

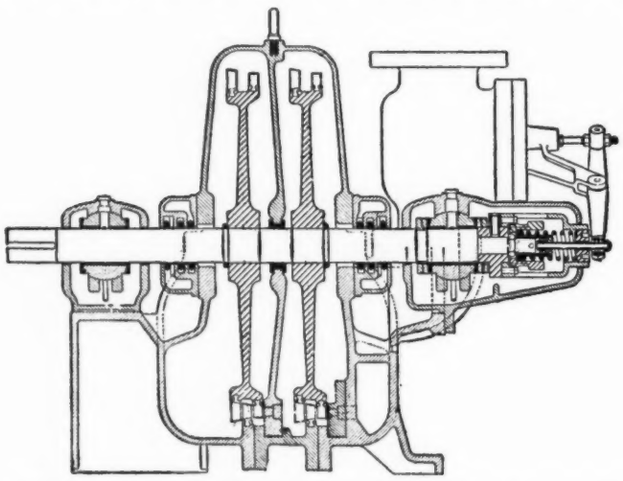

FIG. 1—RIGID CONSTRUCTION PREVENTS MISALIGNMENT

casing part into which is set one-half of a diaphragm. The upper half of the turbine is made in one piece having no nozzles or blades in it and no machine work with the exception of facing of the joint and faces for the packing glands, which contain carbon rings. It is tested hydraulically to double normal pressure.

The main bearings are made either of bronze or babbitt-lined cast iron. They are made in halves and are absolutely interchangeable and removable.

A thrust bearing is on the steam end, being made up by four collars attached to the shaft on threaded sleeves set into accurately machined grooves, permitting adjustment of the rotor in an axial direction and also for wear on the bearing. Inherently, the turbines have no end thrust, but there are causes such as clogging up of blades with foreign material, etc., which may result in end thrust.

Packing rings have a liberal side clearance so as to prevent sticking between the partition walls, due to possible impurities in the steam. They have a large outside radial clearance to allow free movement and prevent possibility of their riding on the case. However, there is a small clearance of one to two thousandths of an inch over the shaft to prevent steam leakage at that point. The rings are made in three segments, held together by a coil spring and prevented from rotating by means of stops set into milled slots.

The rotor weight and the shaft diameter are such that no critical speed will come any nearer an operating speed than 30 per cent. Disks which carry the rotating buckets are shrunk onto the shaft with a shrink fit heavy enough to overcome the maximum tensional stretch at the bore and still have a liberal margin to insure good holding power on the shaft.

Revolving buckets are milled from bronze, cupronickel, or monel metal, depending upon the steam conditions, and are set into dovetailed turned grooves in the wheel, spaced accurately relative to each other by means of accurately machined spacer pieces. Steam spillage on the outside is prevented by bands set into milled slots in the sides of the buckets and braced securely to these buckets. The construction of these shroud bands is such that they are prevented from being thrown off or damaged through the holding power of the buckets themselves. The bracing is not depended upon to prevent this; it merely hinders the rings from sliding out sideways.

The governor is of the centrifugal type and consists of two weights, fulcrumed on knife-edges resting in hardened and ground knife-edge seats in a governor housing attached by means of a housing hub to the shaft. The movement of the weights is resisted by a compression spring against a shaft sleeve, the outer end of the compression spring resting against an adjustable nut screwed into the housing. Adjustment of the speed is secured by screwing down on the spring by means of this nut.

An emergency governor is always provided which will automatically shut down the turbine should the speed exceed the normal speed by a predetermined amount; usually, this amount is 10 per cent. This consists of a plunger inserted into the governor hub, resisted by a spring. The scale of the spring being relatively low and the initial compression fairly high, the emergency trip pin comes out suddenly and strikes the trip lever a decided blow, which will release a heavy relay spring, closing a butterfly valve in the steam-chest casing.

The governor valve is of the hollow poppet type, carefully balanced to prevent undue forces on the mechanism due to static or dynamic pressure. Governor-spring vibration is prevented by carrying one end in the housing and allowing the other to move the sleeve guided by the turbine shaft.

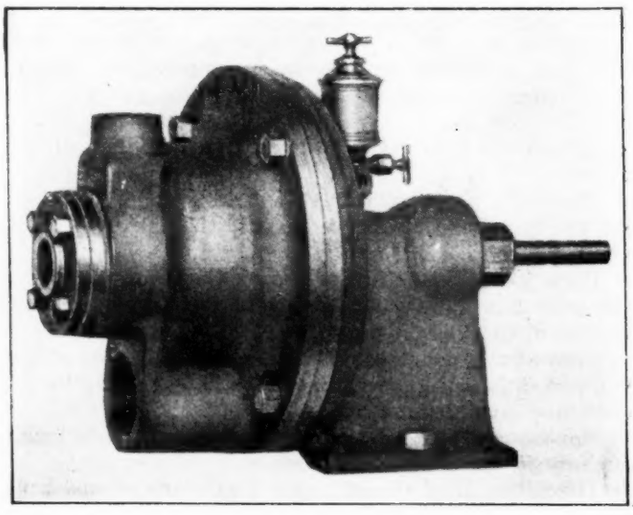

FIG. 2—FOR LOW-POWER DIRECT DRIVE

# EDITORIALS

## Forty Years of Electrical Development

THIS week the New York Edison Company is celebrating the fortieth anniversary of the birth of the central-station industry. It was in September, 1882, that Mr. Edison placed in service the old Pearl Street Station. Although antedated by a few private electric generating plants and one supplying public buildings abroad, this was the first central station to be projected. Its historic "Jumbo" dynamos, driven by 125-horsepower engines, form a marked contrast with the modern 35,000-kilowatt turbo-generators now in general use, and the initial capacity of 600 kilowatts in this first station has expanded to an installed capacity of 14,500,000 kilowatts distributed among 5,700 operating companies throughout the country.

In the early days lighting constituted practically the entire load and the equipment remained idle during the day. It soon became apparent that a motor load that would increase the use factor would be most desirable, and attention was directed toward electric drive. The growth of this industrial load may be grasped by a comparison of the output of central stations for the whole country in 1921 as compared with that for 1887, the earliest year for which we have authentic figures. In 1887 there was generated 175 million kilowatt-hours, of which less than nine per cent was applied to power, whereas in 1921 the total output exceeded forty billion kilowatt-hours, of which industrial power accounted for over sixty per cent. The economic effect is indicated by the fact that in 1882 the customer paid one cent for 16 candlepower-hours whereas he now obtains nearly 150 candlepower-hours for the same price. Moreover, it is significant that three-fourths of this growth has occurred during the last ten years.

Such development is a tribute to the designing engineer, the operator and the far-sighted engineering executive. That the curve is still pointing upward portends an ever-increasing influence of electricity on the industrial growth of the country.

## Heat Balance in Private Plants

OF THE various factors entering into the design of the modern central station, none receives more careful study than the heat balance, for in these days of high fuel prices economies are figured by the closest margins. But the need for a proper heat balance is not confined to the central station; it applies as well to the private power plant, the extent to which it should be carried depending upon the savings as compared with the fixed charges on the necessary equipment.

When an industrial power plant is laid out, the heat balance usually receives some degree of attention, to the extent that the operating conditions can be estimated in advance. However, increases in load or changes in process steam and heating requirements frequently necessitate changes in layout or in operating schedules that totally upset the original calculations.

Right here is where the operating engineer is afforded an opportunity to show his worth. In one well-known office building the engineer, by the substitution of high-speed motor-driven centrifugal pumps in place of reciprocating steam pumps in a number of services, has been enabled to raise the electrical load to a more advantageous figure and effect a large saving in auxiliary steam. This, together with a change in radiator valves that made it possible to heat the upper floors with exhaust steam, resulted in an average reduction during the first six months of this year of nearly fifteen per cent of the steam in spite of an increase of seven per cent in the electrical load.

But this is only one of the many instances where engineers have risen to their opportunities. Each case of this kind provides an incentive for other engineers to survey their plants to discover wherein similar economies may be effected.

## The Oil Engine for Small Industrial Plants

THE coal situation is acute and will continue so for a long time. Even though the strikes are settled and production has resumed, the depletion of reserve stocks has been so complete that many consumers will be on short rations for many months. Federal and state authorities will issue priority lists, and manufacturers will in all probability be allotted limited amounts with resulting reduction in plant capacity.

Manufacturers are giving their power problems more serious consideration today than formerly. Competition is more keen. Prices are relatively low and the volume of business closed is generally not large. Operating costs are being carefully analyzed. Every possible means of securing economy is being scrutinized and investigated. Continuity of operation, as well as low power costs, is indispensable. Power interruptions from lack of fuel have been frequent. Scarcity of fuel means increased fuel costs and increased fuel costs means increased manufacturing costs. Shutdowns decrease income, and overhead piles up just the same. Profits are reduced if not eliminated; surplus disappears if the manufacturer is fortunate enough to have any; and unemployment is increased.

Just at this time an increasing number of manufacturers are investigating the use of oil engines. Here is a solution of the power problem for the smaller manufacturer where the demand for exhaust steam is not a factor and whose requirements are less than two thousand horsepower. Not only do these engines operate with high economy, but they require less labor than do coal-burning plants of like capacity. There are no stand-by losses, no banking of fires, no delay in starting, no ash-removal charges. Less floor space is required; less capital is tied up in spare parts, and the whole cycle of power generation is in one unit.

The present-day oil engine is on the line in less than ten minutes and starts from cold to full load. Economy at one-half load is within twenty per cent of that at

full load. Ordinarily, oil can be delivered by rail, but if necessity arises it can be delivered by truck. There are no strikes on the oil lines. Fuel is always available and cheaper grades of oil can be used satisfactorily.

Only those who have closely followed oil-engine production realize how this industry has grown. The field for installation is wide, including direct-connected or belted units for driving shops and mills, for electric generation, pumping, ice plants, etc. As for location of industries, almost every state is represented. In Pennsylvania, where both anthracite and bituminous coal are mined, and in Virginia and Illinois, where bituminous is mined, oil engines are frequently installed. In fact, one coal mine uses oil engines in its power plant.

## Another Advance in Pressure for Large Boilers

USING high-pressure steam is by no means a modern engineering feat. Dr. Ernst Alban, of Plau, Saxony, tells in his book, "High-Pressure Steam Engine," published in 1843, "When in London I believe I made use of, in my engine, steam of a higher pressure than had ever been emplcyed before. Once I worked an engine for the sake of experiment, to a pressure of one thousand pounds on the square inch; and it was found that under this tremendous pressure the engine itself remained perfectly firm and steamtight in all its parts. On a subsequent examination it appeared that the packing (in the piston) had become somewhat singed and softer than usual; nevertheless it retained the steam perfectly well. This engine was constructed peculiarly for a very high pressure."

The experiments were probably made somewhere around 1830, since the author had spent about thirty years in investigation and the construction of high-pressure engines before writing this book. He goes into considerable detail, which shows that he was familiar with the operating problems that would be involved in attempting to run a plant at such high pressures and temperatures in very much the same way that we are familiar with the difficulties today, and gave up the idea of extremely high pressures for something more rational. Furthermore, he recognized the fact that boilers for high pressures should be constructed with small pressure parts. To accomplish this, he designed and built a water-tube boiler that was similar in many respects to some in common use today.

Contemporaneous with Dr. Albans was John Perkins, who also experimented with high-pressure steam, and in later years Loftus Perkins carried on extensive experiments with the application of high-pressure steam and in 1880 built the yacht "Anthracite," whose engines operated on steam at five hundred pounds.

About ten years ago considerable interest was centered in the Winslow high-pressure boiler with relatively small tubes. It was claimed that pressures up to two thousand pounds could be generated. In an experimental boiler designed for six hundred pounds and three hundred degrees superheat, five hundred pounds pressure and two hundred and eighty degrees of superheat were obtained.

About the time that the Winslow experiments were being conducted in this country, Dr. Wilhelm Schmidt was experimenting in Germany with the use of steam at pressures of over eight hundred pounds in reciprocating engines of special design.

These instances clearly indicate that the advantages to be gained in the use of high-pressure, high-temperature steam have been realized by power-plant engineers for at least one hundred years. However, except in the experimental plant or the automobile not very much has been done with pressures above three hundred and fifty pounds, although for a number of years the probable upper temperature limit of seven hundred and fifty degrees has been approached closely in a number of plants. An exception to this in the way of pressures is that of the North Tees Station in England with four hundred and seventy-five pounds.

When the plant of the Buffalo General Electric was put into operation in 1916 and 1917, it represented the high-water mark in steam pressures and temperatures in large power-plant practice in this country. This plant attracted international attention, and although at that time it was predicted by some authorities that five hundred or six hundred pounds pressure was a probability of the near future, there are still many large plants that seem to favor pressures of about three hundred pounds and a total temperature of around six hundred degrees. There are a few exceptions, but in the main the operator has not taken kindly to pressures and temperatures much above these, as it has been found one thing to design and construct a plant for high steam pressures and temperatures and an entirely different thing to operate the plant and make it give reliable service. However, many of the earlier operating difficulties have been overcome and, after what might be considered a pause at steam pressures of about three hundred pounds the tendency is again to go to higher pressures. A notable example of this is the new plant of the Public Service Company of Northern Illinois, at Waukegan, the boilers of which are described on page 417 of this issue. These boilers, which will operate at four hundred pounds pressure, are of a new design especially adapted to high pressures in large units. Although this is the first time that pressures in excess of three-hundred-and-fifty pounds have been employed in large plants in this country, marine-type boilers have been built for six hundred pounds but they have been small-sized units. The new boiler is a somewhat radical departure from the standard designs that have been employed in large sizes for stationary work up to three hundred and fifty pounds.

An increase in Rankine cycle efficiency is obtained with an increase in pressure up to about eighteen hundred pounds, after which it begins to fall off. However, this increase in efficiency is not in direct proportion to the increase in pressure. With steam at a constant temperature of seven hundred degrees there is a gain of about three and one-half per cent between one hundred and fifty and three hundred and fifty pounds. From this point the curve begins to flatten out, and the gain between three-hundred-and-fifty and six hundred pounds is only two per cent, with an additional gain of two per cent by carrying the pressure up to one thousand pounds.

In the final analysis it is the cost per unit of power delivered and not Rankine-cycle efficiency that determines the economic limit, although the latter is one of the important contributing factors.

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Two Reeds tuned to a common pitch!

The Senatorial champion of the coal interests from Missouri is joined by his newly appointed namesake from Pennsylvania, who pipes a tune against the Cummins measure directed at the coal profiteer.

# PRACTICAL IDEAS from PRACTICAL MEN

## To Prevent Screw Threads Seizing Under High Temperatures

Many engineers and machinists have experienced difficulty in removing nuts from bolts that have been subjected to high temperatures. When a bolt has been exposed to the direct action of hot furnace gases, it is a common occurrence to twist off the bolt before the nut will turn.

When replacing such bolts or nuts, if a coating of graphite grease is applied to the threads, it will be found that the nuts may be readily removed even after continued exposure to severe heat. This procedure is especially recommended for electrical connections inside of core ovens and other electrically heated equipment.

A mixture of graphite and oil is sometimes more convenient to use than graphite grease, but care must be taken to make the mixture as rich in graphite as the oil will allow. The oil or grease acts merely as a binder or carrier for the graphite, and is usually burned away by the heat.

JOHN L. ALDEN.

Philadelphia, Pa.

## Excessive Steam Lap Causes Knock in New Engine

The indicator diagrams here shown were obtained from a new 15x14-in. automatic engine, operating at 265

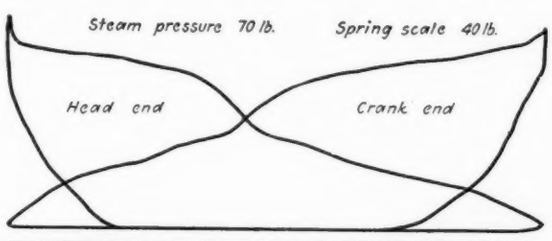



FIG. 1—DIAGRAM OBTAINED FROM NEW ENGINE

r.p.m. and exhausting against a back pressure of 4 lb. gage.

From the first start this engine was noisy, and we were unable to locate the knock until the diagram shown in Fig. 1 was obtained. This card was taken with a load of 52 kw. on the generator. From a study of this diagram we concluded that the valve, which was a one-piece piston valve, had too much steam lap. The valve was removed and $\frac{1}{16}$ in. was taken off the steam lap on each end. When the engine was again put in

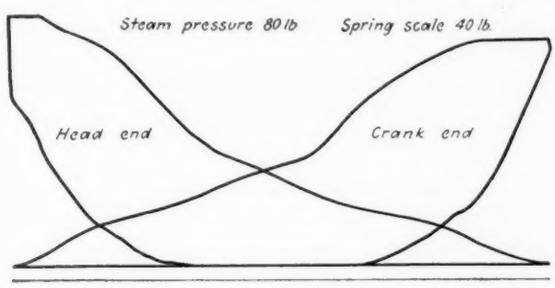



FIG. 2—DIAGRAM OBTAINED AFTER STEAM LAP WAS REDUCED

service, the diagram shown in Fig. 2 was taken with a load on the generator of 41 kw., and the engine ran quietly, the only noise noticeable being the rubbing of the brushes on the commutator.

Detroit, Mich. WALTER MIDDLEDITCH.

## Arrangement of Oil-Burning Equipment

There has recently been installed in our plant a complete oil-burning system for four boilers, and the general layout of the system is shown in the illustration.

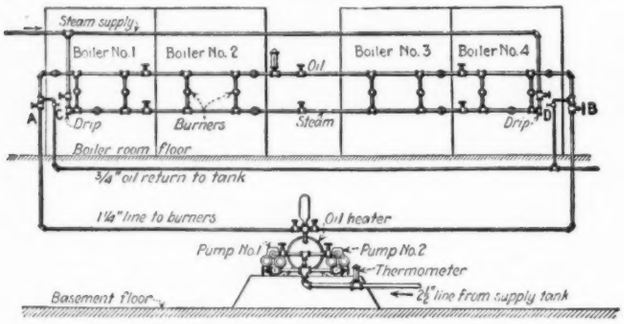
A storage tank of 125,000 gal. capacity is located a short distance from the plant, from which the oil flows by gravity to an underground tank of 6,000 gal. capacity. This tank is fitted with a heating coil, and the temperature of the oil is raised to 120 deg. or higher, either live or exhaust steam being used for heating. Then the oil is handled by a 5½x3½x5-in. duplex pump, which discharges through a heater to the burners. A duplicate pump is installed for stand-by service. The heater is located between the pumps, and the temperature of the oil is raised to 200 deg. while passing through it.

Both the oil and steam piping are installed on the loop system. A return line is connected off each end of the loop between the discharge valve and first burner connection. In normal operation the valve *A* is open and the oil drains back to the suction tank through valve

*D*, or the oil may be fed in the opposite direction by opening valves *B* and *C* and closing valves *A* and *D*.

There is a valve and union on both steam and oil line between each set of burners, for convenience in isolating or removing sections of the piping.

The style of burners used is not shown, but these are fitted with a valve and union on each connection and a burner can be removed and replaced in a few minutes, a spare being kept in readiness. A pressure of 100 lb.




LAYOUT OF PUMPS, HEATER AND PIPING

is carried on the discharge line from the pump, and a quantity of the oil is bypassed continuously to insure the proper temperature being maintained in the oil line.

## Maintenance of Commutators and Brushes

Unless satisfactory results are being obtained from a given set of brushes, assuming that mechanical and electrical conditions favor good commutation, experiments should be conducted, in co-operation with the brush manufacturers, to determine the most suitable brush for the purpose. For use on commutators on which the mica is not undercut, a brush with abrasive qualities should be most suitable, since the mica must be worn down with the surface of the commutator. For commutators on which the mica is undercut, a self-lubricating form of graphite brush is probably best.

If a commutator is grooved, which condition usually develops because of non-uniform brush tension, or incorrect "staggering," or runs eccentric, this mechanical trouble must be corrected before good results can be obtained from any set of brushes. Indiscriminate sandpapering or stoning of commutators should always be avoided. Sometimes annoying vibration will develop in brush-holder arms, and this must be corrected by stiffening or bracing if other means fail.

In most cases, by slotting or undercutting the mica segments of a commutator, commutation can be greatly improved, and most commutators are undercut for this reason. The slots on undercut commutators should be cleaned at monthly intervals with a hand tool and any high mica cut away at this time. After cleaning the slots, each brush should be removed from the holder, without disconnecting the shunts, and wiped clean with a rag. The interior of the holder into which the brush fits should also be wiped clean, and before replacing the brushes, the commutator and brush rigging should be blown free of dirt by compressed air.

Where it is desired to practice economy, and inspections are regularly and carefully made, brushes may be safely allowed to wear to $\frac{1}{8}$ in. from the point where the spring arm will reach its limits of travel, or where some part of the brush may interfere with normal vertical movement.

Brushes should be carefully inspected for wear and spring tension at fifteen-day intervals. New brushes should be fitted to the commutator by sandpapering, and emery cloth should not be used under any circumstances. Lubricants must be sparingly used on any commutator, vaseline, paraffin, engine oil or commutator compound being ordinarily used. If a self-lubricating type of brush is selected, no lubricant should be applied to the commutator.

In order to facilitate brush inspections and to identify individual brushes, each brush-holder arm should be marked with a legible number, beginning with No. 1, and each brush-holder should be numbered, the holder on each arm nearest the commutator end bearing being known as No. 1. It is also well to paint an arrow on the frame or bearing of the machine to indicate the normal direction of rotation.

In order to keep a record of brush renewals the form shown in the figure is useful, and thereon should be entered, under the proper brush number and opposite the proper arm number, the date on which a brush was put in and the initials of the person doing the work. These forms are filed for future reference, thus making

BRUSH RECORD

Motor / Generator _____ Maker

____H.P. ____Kw. ____Volts ____Amps. ____R.P.M. Connection ____

Brush length ____Width ____Thickness ____Diameter ____Brushes per set ____

No. of brush arms ____Brush holders per arm ____Brushes are / are not plated.

Brushes are provided with / without shunts. Brushes are non-lubricating / self-lubricating.

Order from _____ Catalog No. ____

| Arm No. | Brush Number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | |
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| 6 | | | | | | | | | | | | | | |
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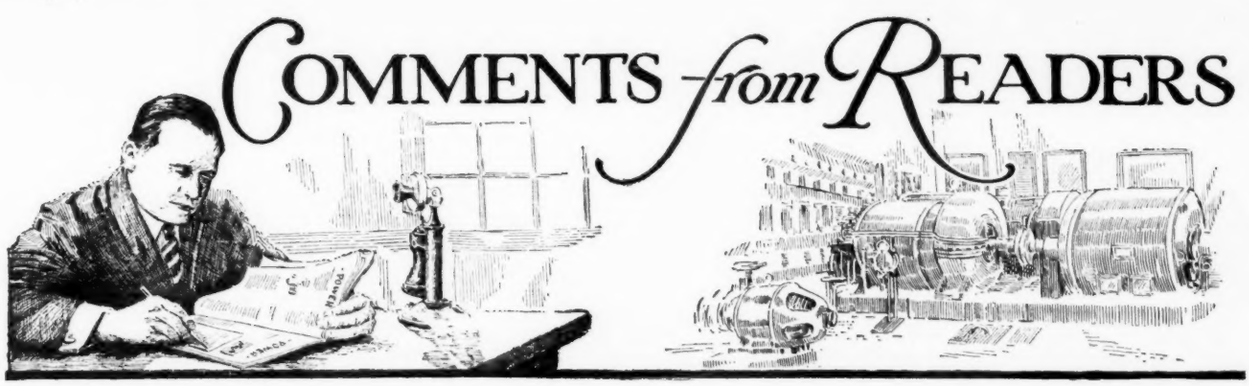
| 7 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | |

FORM FOR KEEPING RECORD OF BRUSH OPERATION

available a record of the life of the brushes. It is apparent that a somewhat similar form may be devised to record the life of collector-ring brushes.

In most stations brush costs form but a small part of operating expense, yet a systematic method of making inspections and renewals is well worth the effort required. Even in the smallest station a liberal quantity of brushes should always be accessible to the men responsible for their maintenance, and sufficient data appear on the brush record card to facilitate ordering new brushes.

RALPH BROWN,
Great Western Power Co.
Belden, Calif.




## Commenting on Painting Radiators

In the article in the Aug. 22 issue on painting radiators the statement is made that recent experiments have shown that the form of paint used on the radiator has no great effect on its heating efficiency, so this question may be disregarded. This statement is, however, open to criticism.

I do not attempt to deny the result of experiments, while at the same time from reliable source we have the statement that painting and the nature of the paints has a pronounced effect on the radiating properties. Taking 1.000 as the value for the bare iron surface, the following values have been derived by experiment: Terra cotta enamel, 1.038; snow white enamel, 1.010; white lead paint, 0.987; copper bronze, 0.760; aluminum bronze, 0.752. The difference between terra cotta enamel and aluminum bronze is almost 28 per cent in favor of the former. This is too large an item to be ignored.

R. G. SPOONER.

New Bedford, Mass.

## Auxiliary Ports in Unaflow Engines

I was quite interested in A. D. Skinner's discussion of the unaflow engine appearing in *Power*, Aug. 29. I wish to point out, however, that Mr. Skinner has made a most obvious error in calculating the weight of steam passing through the central ports.

If the unaflow engine operated on the Rankine cycle with incomplete expansion, and if the steam at release were slightly superheated or even dry saturated, undoubtedly the values given as the percentages of the steam passing through the central and auxiliary exhaust ports would be correct. Dealing with a perfect engine (which the unaflow is not), the adiabatic expansion of steam will cause the formation of some water in the cylinder. If saturated steam at 150 lb. pressure is used and if the exhaust be atmospheric, the quality at ½ lb. gage, which is the release pressure at one-quarter load, would be 89 per cent. This means that within the cylinder is a weight of water equal to 11 per cent of the steam feed.

The unaflow at one-quarter load will not have a Rankine efficiency of over 75 per cent. This means that there is a loss due to heat transfer to the cylinder walls, wiredrawing, etc., of 25 per cent. Of this loss at least 10 per cent may be ascribed to cylinder condensation. The weight of water in the cylinder at release would be the water due to adiabatic expansion in a perfect engine plus the condensation losses in the unaflow. At release in a perfect engine, then, we may expect for each cubic foot of steam, which weighs 0.0385 lb., an amount of water equal to 11 per cent of this, or 0.004 lb. Due to the cylinder losses of the unaflow engine there is an extra 10 per cent that is in the form of water, or 0.00385 lb. The total weight of water in the cylinder is 0.00808 lb. per cu.ft. of steam at release. Of the dry steam in the cylinder the central port discharges, as shown by Mr. Skinner's table, 0.012 lb. Now the water on the cylinder walls evaporates as soon as the central ports are uncovered, and this weight of steam passes out of the central port at release pressure or at some pressure between the release and back pressure. The central port actually handles 0.0012 + 0.0081, or 0.0092 lb. of steam. The auxiliary port, by Mr. Skinner's table, handles 0.0236 lb. The total weight handled is 0.0236 + 0.0092, or 0.0328 lb. The central exhaust at quarter load, then, handles 28 per cent of the total steam fed to the cylinder and not 4.8 per cent as Mr. Skinner indicates.

At full load an error also exists in the table given in the article being discussed. The missing water will be practically the same amount as one-quarter load, or 0.00385 lb. The condensation in a perfect engine would be 6 per cent of the steam feed. The steam weight at 12 lb. release is 0.0654 lb. per cu.ft. The 6 per cent is, then 0.00392, which, added to the missing water (0.00385 lb.) gives a total water weight of 0.00777 lb. The central port, then, discharges this weight of re-evaporated water plus the steam shown in the table (0.0281), or a total of 0.0359 lb. The auxiliary port exhausts 0.0236 lb., a total of 0.0595 lb. for the two ports. The central port exhausts 60 per cent of the total steam feed, and the auxiliary port exhausts 40 per cent.

The difference between Mr. Skinner's figures for full load and those given herein do not differ materially, although the difference at one-quarter load is of some magnitude.

In the original discussion no mention was made of the cylinder condensation and the effect of its re-evaporation on the cylinder temperatures. Since the water passes out through the central exhaust at each stroke, there must be absorbed from the hot piston head and cylinder walls heat sufficient to re-evaporate this water at, say, atmospheric pressure. At full load this means $970 \times 0.00777 = 7$ B.t.u. per stroke. The exhaust steam passing through the auxiliary port, having a weight of 0.0236 lb., even though superheated from 216 deg. to 366 deg. F. (150 deg. superheat), would absorb only 60 B.t.u. per pound, or 1.416 B.t.u. per stroke. It is apparent that this heat absorption by the dry saturated exhaust steam passing through the auxiliary valve is of little moment.

The chief advantage of the unaflow engine seems to lie in the rejection of the condensation water at a point

removed from the hot head. The effect of the heat absorbed to re-evaporate this water is not as bad as in case of a four-valve engine where this water is re-evaporated as it passes across the cylinder head and robs the hot head of this heat.

The merits of the central exhaust port have been extolled beyond their actual value. A high-grade four-valve engine with steam-heated head and using superheated steam is practically as economical as the unaflow. This apparently proves that the actual advantage of the central exhaust lies in the fact that it permits the condensation to pass out at a point when the re-evaporation does not effect the engine to a great degree. With superheated steam the quality of the mixture at release may be 100 per cent and the advantage of the central exhaust then disappears.

New York City. JOHN M. CASSIDAY.

## Using Gasoline Engines for Breakdown Service

With reference to Mr. Busek's letter in the Aug. 15 issue on "Using Gasoline Engines for Breakdown Service," it is my opinion that a steam plant consisting of one 150-hp. engine of the Corliss or unaflow type and two boilers of 1,500 sq.ft. heating surface would be a more practical installation than the one suggested in Mr. Busek's letter.

The letter states that one engine only will be operated, hence it would not seem necessary to install two of these units, for if some spare parts are kept on hand, and ordinary care is observed in operation, no serious interruption should occur.

With a good unaflow engine running condensing, a horsepower should be developed on about 3 lb. of coal and running non-condensing, on about 4½ lb. The trouble with scale in the boiler, as stated by Mr. Busek, could no doubt be eliminated to a large extent by treating the water before it enters the boiler or by the use of a boiler compound. L. B. SHIELDS.

Chicago, Ill.

## The Insulation of Furnace Walls

The heat-loss computations in H. T. Matthew's article "The Insulation of Furnace Walls," in *Power* for Aug. 8, are based on the assumption that the resistance to heat loss through a wall composed of layers of various bricks is the sum of the resistances of the separate layers of brick. It has been repeatedly shown that the resistance to heat transfer through a plate of iron, firebrick or other substance two inches thick is not twice the resistance for a plate one inch thick when, as usually taken, these resistances include the surface contact, as from the magnitude of the figures these apparently do.

I have had considerable experience with boiler settings insulated with porous insulating bricks. From a working point of view the types of wall shown are not practical. From their very nature the insulating bricks are not strong enough to serve as a bond under the strains set up by unequal expansion. Metal bonding, either in the form of wire netting or flat bar ties, is equally bad, as it burns out in a few months and leaves the wall unsupported.

There are two ways to build a satisfactory insulated setting. For the first method, as shown in Fig. 1, build a firebrick wall that will stand of itself, say 13 in., allowing every fifth course to project as headers to tie into the insulating brick—the firebricks have body enough to make a real bond—and then surround the brickwork with a steel casing to protect the insulation, hold it up against the firebrick and prevent air leakage even though it cracks. For high settings the wall must be supported in sections on the steel casing framework or there will be enough shrinkage and settling to cause trouble.

The second method, as shown in Fig. 2, is as follows: Build 9-in. walls of fire and red brick respectively. Bond them together with these bricks carried through in interlocking header courses, and then put between them as much insulating brick as you feel you can afford. This will give a wall in which the firebrick lining will not peel off from the rest of the brickwork and fall in on the fire.

The outside temperature of a boiler wall is less influenced by the conductivity of the bricks in the wall than by its porosity and the draft inside, which cause a circulation of air through the wall, carrying the heat back into the boiler and cooling the outer surface of the wall. Applying coatings to stop air leakage through the setting is usually accompanied by a rise in temperature of the surface of the wall.

Gas analyses taken simultaneously from the firebox and at the damper on water-tube boilers with good tight settings, and operating around 125 per cent of rating on natural draft, showed approximately 20 per cent of the air supply entering through the setting, and

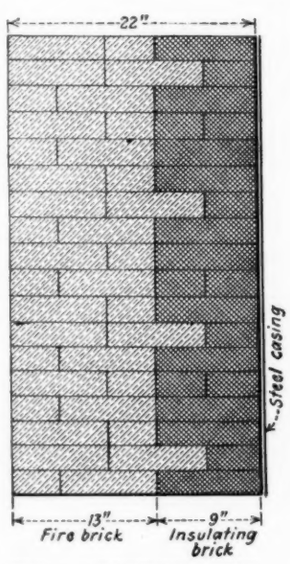



FIG. 1—BONDING FIREBRICK TO INSULATING BRICK

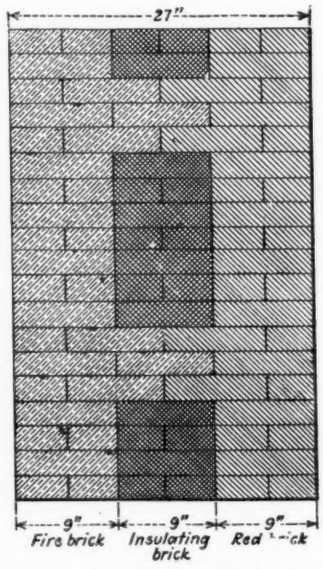



FIG. 2—USING INSULATING BRICK AS A FILLER

on settings that were noticeably cracked, up to 50 per cent of the air supply.

I think the estimated saving of 0.7 of the radiation loss (as given in the opening paragraph) cannot be obtained in practice. Moreover, it seems likely that of the losses that go to make up the item of radiation and unaccounted-for losses, the radiation from the brickwork of the setting, as distinguished from that of the iron work of fire and observation doors and frames, is smaller than Mr. Matthew's figures indicate, and the temperatures lower, so that this article overrates the advantages of insulating the walls and altogether neglects

the difficulties of weak and cracked settings, with corresponding air leakage and losses up the stack.

Swarthmore, Pa. A. D. FISHER.

[The foregoing letter was referred to Mr. Matthew, who submitted the following reply.—Editor.]

Your correspondent, A. D. Fisher, in commenting on statements made in my article on "The Insulation of

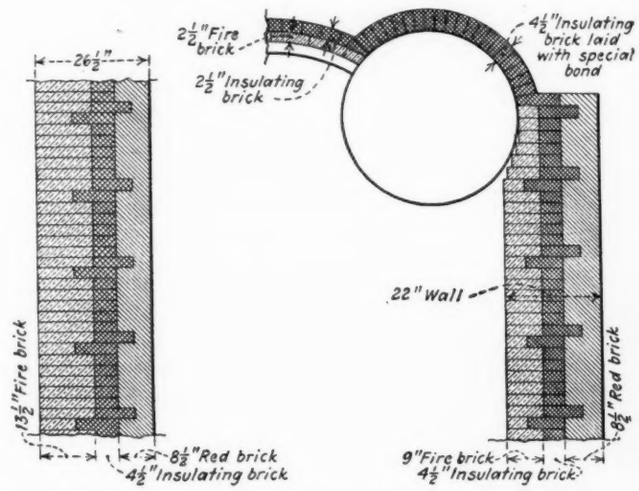



FIG. 3—TYPES OF CONSTRUCTION POSSIBLE WITH INSULATING BRICK

Furnace Walls," appears to have misinterpreted the basis of calculation, as well as the object of the diagram, and overlooked the character of insulation specifically referred to in the article.

The assumption that the surface resistances are included in conductivities used is incorrect. The curves are based on the constants for internal conductivity of components. They do not include surface resistance to heat transfer on the inside of the wall nor the emissivity of the outer surface. When considering a *difference* of heat flow, as in my article, the effects of the surface drops partly cancel.

The diagram of walls was *not* intended to illustrate construction methods, but rather to give a graphic presentation of the application of insulation to several standard thicknesses of walls. A more precise diagram showing the method of applying an insulating course in boiler-furnace walls is shown in Fig. 3.

Comparing this with the construction shown in Mr. Fisher's diagrams of wall sections, it will be seen that the insulating course is continuous, whereas the construction he shows either reduces or omits the insulation at header courses.

This construction, as well as the use of insulating brick, for an outside course without metal casing, can be carried out when the brick used are sufficiently rugged. Fig. 4 shows such a wall.

In my article I referred especially to a brick that would show no shrinkage under a pressure of 40 lb. per sq.in. at 1,900 deg. F. Such brick have a crushing strength exceeding 36 tons to the square foot and have shown by test a modulus of rupture of 200 lb. per sq.in., when supported on the 4½x9-in. face on knife-edges 8 in. apart and with load applied at the center. Insulating brick of this type *can* be tied in as an integral part of a furnace wall.

In relining some marine boilers where this character of insulation had been in use for two years, the insulating brick were found to be in as good condition as when first installed, and in tearing out the old firebrick, most of the insulating brick were salvaged.

As to the percentage of loss due to radiation in the average plant, Bulletin 97 of the Bureau of Mines gives an arbitrary 5 per cent. My statement in the opening paragraph was that "for the average boiler under average operating conditions, this loss is at least 4 per cent." That about seven-tenths of this loss can be prevented by insulation properly installed is neither a new nor an extravagant claim. It does assume, however, that the firebrick are properly bonded with thin cemented joints and that the setting is free from leaks.

On the final point of Mr. Fisher's statement, I fully agree; namely, that my article "altogether neglects the difficulties of weak and cracked settings with corresponding air leakages and losses up the flue," but that was not the topic discussed in the article. Leaky set-

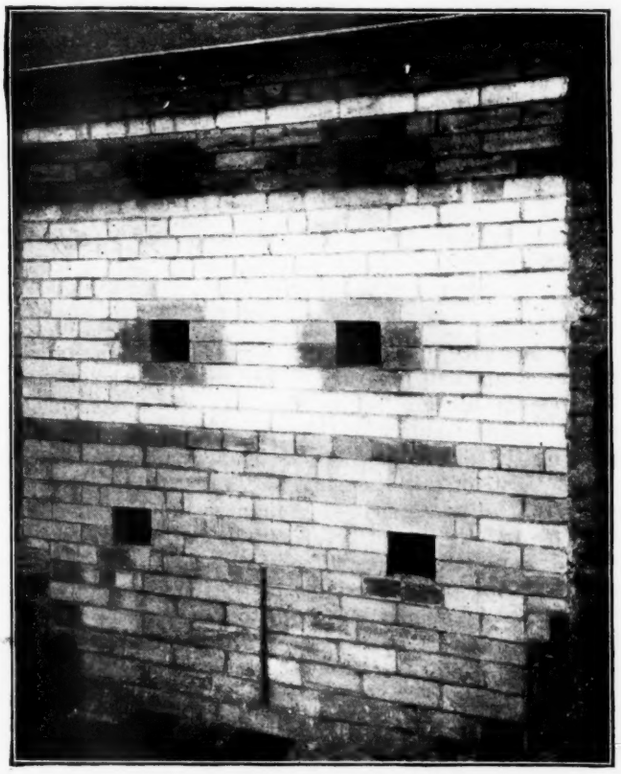


FIG. 4—INSULATING BRICK USED AS AN OUTSIDE COURSE
Brick surrounding the square ports are firebrick—the rest insulating brick, showing how insulation can be bonded with firebrick.

tings in the average plant may easily account for 30 per cent of the gases that pass through the uptake, but this matter scarcely comes within the province of relative heat conductivities. H. T. MATTHEW.

New York City.

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A concrete instance of the disparity between salaries paid those who work with their brains and those who work with their hands is cited by Clifford M. Holland. In a letter to Director Bain, of the U. S. Bureau of Mines, Mr. Holland tells of an instance at a Middle Western University which just has come to his notice. Apparatus was being constructed for some very important research work. Carpenters engaged on the work received $2 per hour whereas the scientists who used the apparatus in their research work received $1 per hour.

# QUESTIONS AND ANSWERS

### Noise of Shaft Governor

We are troubled with a rattling and pound of a shaft governor on the limit stops whenever the engine is started up or shut down. How can this be prevented? T. C. P.

There is more or less noise of that kind with all shaft governors. The stops usually are made sufficiently substantial to take care of the rattling or hammering. However, if the noise is objectionable, it would be best for you to communicate with the manufacturers of the engine.

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### Temperature Alone Not a Measure of Vacuum

Why cannot the temperature of the steam in a condenser be taken as a measure of the vacuum? W. W. B.

The pressure in a condenser is made up of the tension of the steam and pressure of air that may be present. The steam tension is the pressure of dry saturated steam at the temperature of the mixture, and the tension of the air at the stated temperature depends on the weight of air present per unit volume of the mixture. A greater or less quantity of air always is present and the quantity of air in the mixture is not deducible unless the pressure of the mixture is known. Hence the back pressure due to a condenser cannot be ascertained by simply referring to steam tables to learn the pressure corresponding to the temperature, because the pressure so found would be only part of the total back pressure, as it would not include pressure due to the presence of air.

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### Foaming and Priming of Boiler from Concentration of Soda

Since installing a softening process for the feed water supplied to a laundry boiler, it has foamed badly and we have had much trouble to keep one gage of water on account of priming of the water over into the engine. How can the foaming be prevented? L. H.

Undoubtedly, the foaming is due to concentration in the boiler of soda introduced in the water-softening process. The boiler should be thoroughly washed and cleaned and to prevent the concentration becoming so excessive as to cause foaming it should be blown down about one gage two or three times a day and washed out at least once in two weeks. If that course is not found effective in stopping the priming, the number of times of blowing down each day should be increased and there should be shorter periods between the times of washing out the boiler.

### Testing Leakage of Check Valve

How can it be determined whether a boiler-feed check valve leaks? G. C.

When pump valves and water pistons are not perfectly tight and the feed-stop valve is left open when the pump is not running, the hot boiler water will be forced back to the pump and the check valve leakage is revealed by a higher temperature of the feed pipe near the boiler than when the pump is feeding the boiler. A surer test of the check-valve leakage is to tightly close all direct supply connections to the check valve. Then with boiler pressure on the discharge side, test for leakage by bleeding any direct supply connection between its stop valve and the inlet side of the check valve.

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### Choice of Ejector or Duplex Pump for Handling Hotwell Water

At our plant a steam ejector is operated intermittently for delivering the water of a hotwell to an open feed-water heater. Would it be more economical to graduate the admission of steam to the ejector to obtain continuous operation and obtain more constant feed-water temperature or use a small duplex pump exhausting to the heater? J. F. G.

Continuous operation of the ejector or of a duplex pump would be more economical than intermittent discharge to the heater. Where the heat of the pump exhaust or the heat transmitted to the water by an ejector is utilized, the difference of economy between a pump and steam ejector would be so small as to be negligible. The ejector would have the advantage of directly heating the water delivered to the heater and the probable disadvantage of giving trouble in adjustment to the requirements, while the pump, although easier of adjustment, would depend on the efficiency of the heater for transmitting the heat of the exhaust to the feed water.

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### Bending of Fire Tubes of Horizontal Return-Tubular Boilers

What causes fire tubes of a horizontal return-tubular boiler to become bowed upward? W. G. B.

The upper part of the tube becomes heated more than the lower part, and that is especially true when the tube is permitted to become gradually dry from lowering of the water level while there is fire under the boiler. Due to a higher temperature of the upper side, it expands more than the lower side, and with the tube ends rigidly held in the tube sheets, the relative difference of temperature of the upper and the lower sides produces an upward arching, as would be the case should there be

shrinkage of the lower side from reduction of its temperature below that of the upper side. When the tube is thus deflected, especially when there has been severe overheating of the upper side during a lowering of the water level in the boiler, the tube material assumes a permanent set in the bowed form.

Another cause for deflection in a particular direction is relaxation of irregular tension in the tube material, which may have been introduced in the manufacture or from straightening or other handling of the tube.

### Percentage of Clearance of High-Speed Engines

Why is the percentage of clearance greater in high-speed than in low-speed engines? H. W.

The term "high speed" is most commonly applied to shaft-governed single-valve engines of shorter stroke than slow-speed single-valve engines of the same bore of cylinder.

The long and large steam passages required in single-valve engines, together with the necessary mechanical piston clearance, makes the actual clearance space as great as for a slow-speed single-valve engine of the same diameter of cylinder. But having a shorter stroke, the cylinder clearance space becomes a larger percentage of the piston displacement.

In four-valve high-speed engines with non-releasing gear, the actual cylinder clearance volume may be as low as in an engine of the same diameter of cylinder and slower rotative speed, but as usually designed, the stroke is shorter in proportion to the diameter of the cylinder than in slower-speed releasing gear engines of the same diameter of cylinder and same piston speed; therefore the same actual clearance becomes a larger percentage of piston displacement, although less than in the single-valve engine of the same diameter and stroke, because the actual clearance is less.

### Cast-Iron Piston Rings

What is the usual turned diameter and thickness of cast-iron piston rings for steam pistons? J. N.

The usual rule for piston rings when made of cast iron is to turn them out of the solid $\frac{1}{4}$ in. larger than the cylinder diameter for cylinders 20 in. in diameter, and then cut out enough to spring the ring to the diameter of the cylinder. For larger or smaller cylinders the greater diameter for turning the ring out of the solid and the amount to be cut out is in proportion. That is, a ring for a 15-in. cylinder would be turned off, solid 10$\frac{3}{4}$ in. diameter and then have enough cut out to be sprung to the diameter of the cylinder.

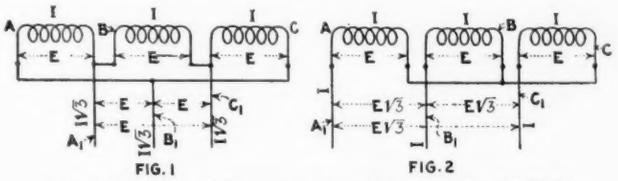
The thickness is commonly made $\frac{1}{30}$ of the cylinder diameter plus $\frac{1}{8}$ in., and the width is made equal to the thickness plus $\frac{1}{4}$ in. Hence for a 15-in. cylinder the thickness would be $\frac{15}{30} + \frac{1}{8} = \frac{5}{8}$, and the breadth would be $\frac{5}{8} + \frac{1}{4} = \frac{7}{8}$ in.

For an eccentric ring—that is, with the thickest part diametrically opposite to the cut ends—the average thickness is made the same as for a ring of uniform thickness and the thickness at the place where the ring is cut is made two-thirds of the greatest thickness. Thus, for a 15-in. cylinder the average thickness of an eccentric ring would be $\frac{5}{8}$ in., the thickest part would be $1.2 \times \frac{5}{8} = \frac{3}{4}$ in.; the thickness at the cut ends would be $0.8 \times \frac{5}{8} = \frac{1}{2}$ in.; and the width as for a ring of uniform thickness for the same diameter of cylinder would be $\frac{7}{8}$ in.

### Calculating the Power Transmitted in a Three-Phase Circuit

Why it is necessary to multiply the product of the voltmeter and the ammeter readings in a three-phase circuit by the $\sqrt{3} = 1.732$ to obtain the apparent watts? S. D. H.

By referring to Figs. 1 and 2 it will be seen that the voltmeter and ammeter readings, as obtained from the three leads of a three-phase circuit, are not necessarily the volts and current per phase. In Fig. 1 the three windings, $A$, $B$ and $C$ are connected in delta. With this connection the voltage between the leads $A_1$, $B_1$ and $C_1$ is the voltage per phase. Leads $A_1$ and $B_1$ connect directly to phase $A$, therefore the same voltage exists between these leads as that across phase $A$. Lead $A_1$, however, connects between phases $A$ and $B$, consequently the current flowing in this lead will be the resultant current in the two phases, and in a balanced circuit if $I$ represents the current per phase, $I\sqrt{3}$ represents the current per terminal, which is what the ammeter will read. Then if the voltmeter reading, $E$,




CALCULATING POWER TRANSMITTED IN THREE-PHASE CIRCUITS

is multiplied by the ammeter reading, $I\sqrt{3}$, we have $EI\sqrt{3}$. From this it is seen that when the voltmeter reading is multiplied by the ammeter reading, we do not have the apparent watts per phase, but the apparent watts times the $\sqrt{3}$, so that to obtain the total apparent watts it is only necessary to multiply the two readings by the $\sqrt{3}$. This gives the equivalent of $EI\sqrt{3} \times \sqrt{3}$ or $EI \times 3$.

In the star connection, Fig. 2, the leads $A_1$, $B_1$ and $C_1$ connect to individual phases, therefore the current per lead or the ammeter reading is the current per phase. The voltage between any two of the leads, $A_1$, $B_1$ and $C_1$, is the resultant of the volts of two phases in series. For example, between leads $A_1$ and $B_1$ windings $A$ and $B$ are connected in series. Since the voltage in the two windings have a phase relation of 60 deg. the resultant voltage between leads $A_1$ and $B_1$ is equal to the voltage of one phase times the $\sqrt{3}$, or $E\sqrt{3}$. From this it is evident that the product of the voltmeter reading times the ammeter reading is not the volts per phase times the current per phase, but the volts per phase times the $\sqrt{3}$ times the current per phase. By multiplying this product by the $\sqrt{3}$ gives the apparent watts, or the equivalent of 3 times the volt per phase times the current per phase. From this it is evident that in either a delta or star connection the apparent watts, for a balanced load on a three-phase circuit is equal to the voltmeter reading times the ammeter reading times the $\sqrt{3} = 1.732$.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

# The Stoker from an Operating Viewpoint*

By Robert E. Dillon
Edison Electric Illuminating Company of Boston

Five things must be taken into consideration in contemplating a station of any description. These are reliability, maintenance, efficiency, cost of operation, and first cost.

Little needs be said on the subject of increasing the reliability of the stoker; as a unit this is one of the most reliable pieces of apparatus in station equipment provided it is worked continuously while operated and maintained intelligently. The statement is qualified because it is felt that there is room for improvement in design to provide against undue depreciation while in banked condition and to insure that the stoker is not put out of commission during the banked period or while bringing from banked to steaming.

### Further Reduction of Maintenance Costs Possible

With regard to maintenance, due respect must be paid to the manufacturer as represented here today for the advance made in reducing this item; but there is still a chance for further improvement. Particular reference is made to those parts on the stoker where the wear is greatest, emphasizing that the construction be made so that these parts can be renewed separately without unnecessarily replacing large portions of the stoker that are not worn.

In discussing the efficiency of the stoker, if inefficient auxiliaries are required, then the use of them must manifestly be charged up against the stoker.

The operator is bound by limitations of design over which he has no control. With a definite load to maintain efficiently, a definite amount of coal is required. The size and distribution of the air holes in the grates and the grate area are fixed quantities for the operator. These two items should be so accounted for in the design that for continuous operation at uniform rates, a fuel bed can be maintained of such shape and thickness that the proper amount of air will pass for the efficient burning of the coal which will approach 100 per cent combustion before reaching the grinder pit. The importance of this cannot be measured by the space which it takes to tell it.

It is realized that the furnace can not be designed to meet uniform conditions of service and at the same time provide wide and rapid change in the rate of forcing without some sacrifice of efficiency; however, the design should be such that the change can be made without undue throwing of the coal by the air, so that the contour of the fuel bed may eventually be brought back to give efficient operation.

The effect on over-all efficiency of the three auxiliaries which are directly pertinent to the operation of the stoker are the ash-removal apparatus, the stoker drive and the forced-draft apparatus.

### The Ash-Removal Drive

The ash-removal drive is a simple thing, independent, or driven from the main stoker drive. It is generally conceded that it is not feasible to operate the clinker-removal system continuously in synchronism with the stoker drive, but that it is better to adopt a policy of intermittent operation in order to allow for variations of ash content in the coal and for the different rates of forcing the stoker. There is one objection to this method of operation which must be noted.

As the grinder always removes the refuse faster than it is made, the responsibility for keeping the clinker grinder from burning out is left to the operator. For this reason, it has been found desirable to speed the grinder up to a point where it is necessary to operate it only a few minutes out of each hour in order to reduce the liability that the operator will forget that it is grinding.

When the coal reaches the clinker pit, it is nearly all ash and there is then very little decrease in volume. However, almost invariably the clinker pits are designed with decreasing volume as the ash proceeds on its way. This particular mistake in design is causing a large part of the trouble met with today with clinker grinders.

The question of using power or hand-operated dump must be decided with other conditions in the plant in mind. Usually, a saving can be made in labor and capacity by the use of power dumps.

The stoker drive must be variable, either by means of gears or by variable-speed motors, and as these methods are well standardized, little can be said from the viewpoint of efficient operation; but while discussing the coal feed, it should be pointed out that the same mistake is made as in the grinder pit. Why decrease the size of the hopper as the coal feeds down closer to the ram?

### Variable-Speed Fan Most Desirable

The third auxiliary, the forced-draft apparatus, when operated efficiently, has characteristics fortunately suitable to the stoker requirements. The volume of air needed in the furnace varies as the rating. The pressure of the air to obtain the required flow varies approximately as the square of the rating. With the fan, the volume of air delivered depends on the fan displacement and varies as the speed for most economical operation. The pressure at the fan outlet depends on the tip speeds and varies as the square of the speed for the point of most economical operation. Consequently, here is an auxiliary that can be fitted efficiently to the operation of the stoker at any rating if it is made of variable speed.

If it is attempted to regulate the furnace by throttling the air by means of dampers, the advantage in economy, as pointed out, will be last. If the variable-speed fan does not prove possible, other things considered, then a compromise ought to be made by running several fans to a common duct serving several boilers, and by arranging to take fans out of operation in order to maintain the desired conditions. By following this method, the efficiency will be impaired only when the pressure is not carried at an economical point for the given speed. The delivery of air per fan can be maintained approximately constant and thereby efficient.

The cost of operation of the stoker is affected by both the design and the method of operation. The admission of air through the brickwork of the side walls and side air boxes has done much to cut down cost of operation as well as maintenance, owing to absence of clinkers. The increasing amount of air added above the fire, however, will have to be taken into consideration in the design of the stoker as its use is extended to other parts of the furnace, as is the tendency in new layouts.

The designer of the stoker should do everything possible to reduce siftings. Accumulations increase operating cost due to labor of removal and to the moral effect of working in untidy surroundings.

There has been given to the boiler operating man as good apparatus as can be bought and the same amount of refinement in instruments that are found in the engine or electrical operating room.

### Responsibility of Boiler-Room Foreman

The boiler room foreman is responsible for having a sufficient number of boilers lighted to take care of the daily peak and the proper number steaming to give best efficiency at all times. The load is indicated on a load sign located in the boiler room. The fireman, with the knowledge of the load to be carried per boiler, has curves indicating how much coal he must burn in each furnace to produce the necessary steam. The tachometers are scaled in pounds of coal being fed and are provided with a secondary scale which indicates the approximate air pressure to be maintained in order to supply the right amount of excess air to burn the coal efficiently. Draft gages indicate pressure under and over the fire. The dampers (or fans if induced-draft fans are in service) are regulated to bring the draft over the fire to a slight vacuum, usually about one-tenth inch.

Draft instead of pressure is better over the fire for reasons of efficiency, although the latter would overcome

*Abstract of paper presented before the Annual Meeting of the Stoker Manufacturers Association, New London, Conn., June 21.

any tendency toward infiltration. The danger of air blowing out through the doors when they are opened and the advantage in maintaining the furnace walls and stoker iron favor a slight vacuum.

With the improvements in method of operation and in design of the stoker, the labor of operation has been reduced to a minimum. Today there is being produced 60,000 kw. with three men, two of these being rated as water tenders and stoker operators and the other as greaser and oiler and general-utility man. The stoker has been brought to a degree of perfection where from the labor viewpoint, there is no advantage in burning oil.

It has been very generally conceded that the underfeed stoker is better adapted for burning coking coals and that the chain-grate stoker is superior for Western non-coking coals and the side feed for some other conditions. The men assembled here have submitted the stoker designed for regular trade to fulfill conditions that require entirely different treatment in design.

Heating the feedwater by bleeding the main units is making the installation of economizers harder to justify in large power plants. The heat from the flue gases, however, cannot be wasted and preheaters will be forced into use. Apparatus for this purpose, which is now effectively in use abroad, will undoubtedly be introduced into this country, and air will then be delivered to the boiler at 200 or 300 deg. F., and there will be need for redesigning grate airflow passages to meet the new requirements in order to maintain the present good results in maintenance.

## Coal Control Bill Passes in Senate After Sharp Debate

Delayed by discussion of the industrial situation by members of both parties and by attacks upon its constitutionality, the Cummins bill to regulate the distribution of coal and to control prices by denying cars to operators who charge more than a "just and reasonable price" for coal for interstate shipment was finally passed in the Senate on Sept. 7, by a vote of 40 to 7.

Aside from the question of constitutionality the most serious assaults against the Cummins bill were based upon the fear expressed by some Senators, notably Dial of South Carolina and Sutherland of West Virginia, that it would annul or invalidate contracts for coal. Both of these Senators offered amendments that contract coal should not be included within the provisions of the bill, but this met objection by Senator Cummins, Senator Kellogg and Senator Lenroot that any exception would nullify the act.

Senator Sutherland secured adoption of an amendment, to which Senator Cummins did not offer objection, limiting the life of the bill to six months from the date of its passage. In the original form the bill would have existed a year. The House bill on the same subject limited the time to Jan. 1, 1924, after originally having been proposed as a permanent measure.

Senator Underwood of Alabama, the Democratic leader, described the bill as useless, contending that the Interstate Commerce Commission has full authority to issue priority orders under the Transportation Act and that attempts at price fixing would be futile.

Senator Sutherland objected strenuously to the price-control features of the measure, contending that they would work hardship on operators who had played fair under the Hoover voluntary agreement, while grasping operators would be able to sell in intrastate commerce free from the terms of the bill.

Great loss to industrial plants because of increase in price of coal above their contract prices, made possible by "fair price" regulations, already has been suffered and more will ensue under the pending bill, Senator Dial contended.

Senator Cummins vigorously defended the constitutionality of the bill, as did Senator Kellogg, while Senator Lenroot joined in declaring the emergency in coal supply to be such that a drastic step is necessary to assure an equitable distribution of fuel at reasonable prices.

The bill empowers the Interstate Commerce Commission to issue priority or embargo orders regarding coal and creates the office of Federal Fuel Distributor, such official to investigate supply and demand, usual prices and current prices and to make recommendations to the Interstate Commerce Commission.

An amendment offered by Senator Dial was adopted, providing that laws regarding the assignment of cars shall not be effective on coal contracts entered into prior to July 25, 1922, where the price is not more than $2 a ton f.o.b. at the mines.

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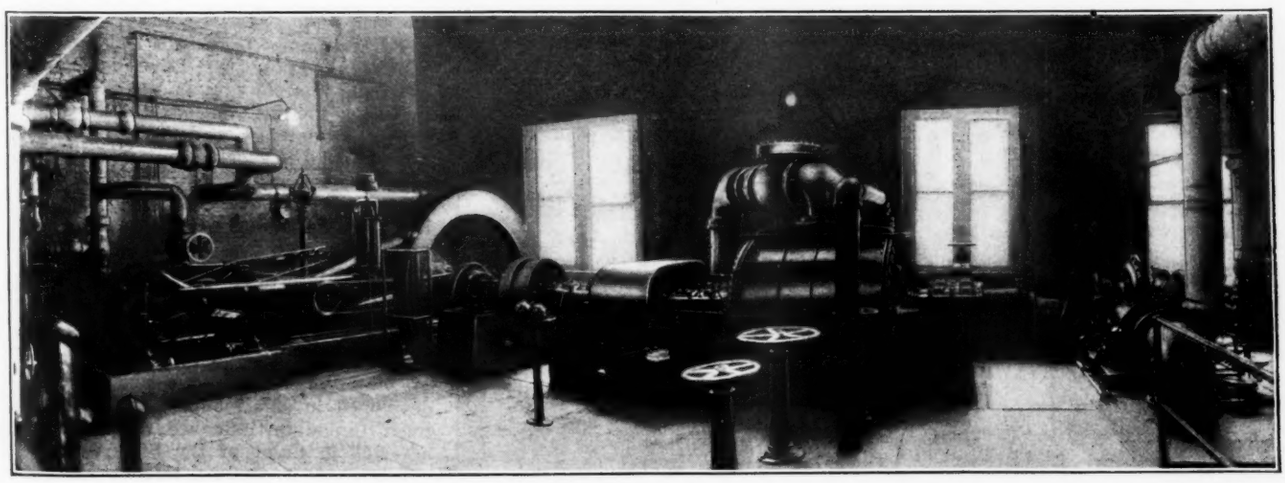
Over a million potential hydro-electric horsepower is available in the rivers of Bulgaria, according to a report of the United States Chamber of Commerce. It is stated that only about 150,000 hp. would be required primarily for the electrification of railways and industries, leaving the balance for lighting and industrial purposes. Where the structures required are of such magnitude as to become national utilities, it is proposed that the state undertake their execution; those for local service would be undertaken by syndicates formed for that purpose. The state program recognizes that the aid of foreign companies is necessary, because of their superior technical knowledge, construction methods and equipment; to enlist such aid, all the work finally decided upon will be extensively advertised abroad.



THE OLD WAY OF BLOWING GAS
Engine-driven positive displacement blower; capacity 325,000 cu.ft. of gas per hour; maximum pressure, 5 lb. per sq.in.

THE NEW WAY
Turbo - blower; capacity 450,000 cu.ft. of gas per hour; pressure, 6 lb. per sq. in.

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# News in the Field of Power

### British Engineering Societies Federate

Further evidence of the movement toward international co-operation among engineers is found in the announcement that the leading engineering societies of England have formed the Engineering Joint Council, which will work with the engineering societies of the United States and of Canada and the other British possessions "to bring about concerted action for world peace and the advancement of engineering ideals for the good of mankind."

Charles F. Rand, chairman of the Engineering Foundation, describes this union of British engineering bodies as a big step forward in the movement to form a world union of engineers, which movement has already gained great headway in France, Italy and Czechoslovakia. Direct contact has been established between the engineering bodies of those counties and of America.

Coincidently with Mr. Rand's statement, Dean Mortimer E. Cooley, of the University of Michigan, announced that the Federated American Engineering Societies, of which he is president, has appointed a committee on affiliation with engineering societies outside of the United States. Gardner S. Williams of Ann Arbor, a former member of the Michigan faculty, is chairman.

The British Engineering Joint Council was formed, according to Mr. Rand, as a result of the recent trip abroad of a mission of thirteen American engineers for the purpose of conferring the John Fritz medal upon Sir Robert Hadfield, of London, and upon Eugene Schneider, of Paris, head of the Creusot works.

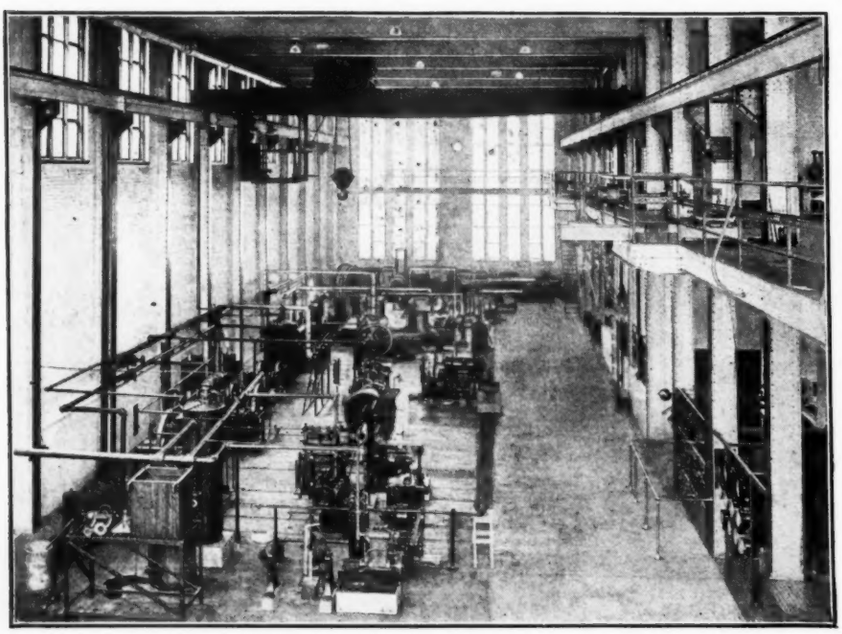
The organizations represented on the British Council, the oldest and most famous of British engineering societies, include the Institution of Civil Engineers, Institution of Mechanical Engineers, Institution of Naval Architects, and the Institution of Electrical Engineers. One of the objects of the British Union of Engineering Societies is similar to that which actuated the formation of the Federated American Engineering Societies, namely: "to secure better utilization of their services in the country's interests."

### Machine-Tool Makers To Exhibit at New Haven

An exhibition of machine tools at which there will be no charge for exhibition space and no admission fee for spectators will be held in the Mason Laboratory of Mechanical Engineering, Yale University, New Haven, Conn., Sept. 21-23, under the combined auspices of Yale University and the Connecticut section of the American Society of Mechanical Engineers.

The use of the Mason Laboratory was offered by Yale University in appreciation of the courtesies extended to its students by the manufacturing plants in the vicinity of New Haven. The manufacturers who will exhibit, however, are by no means confined to New England. Representative machine-tool makers from as far west as Chicago will take part. The exhibit will be held in connection with the regular fall meeting of the Connecticut section of the A.S.M.E., and as there have been no meetings of the section since last spring, the coupling of this meeting with the machine-tool exhibition will give it very much the character of a convention.

Kenneth F. Lees is chairman of the executive committee in charge of the exhibit, and Harry W. Westcott is general exhibition chairman.



SCENE OF THE COMING MACHINE TOOL EXHIBIT: MASON LABORATORY, YALE UNIVERSITY

### To Develop Tallapoosa River

The Alabama Power Company has filed application with the Federal Power Commission for a large hydro-electric power development on the Tallapoosa River. The application calls for the construction of four dams with a total capacity of 140,000 hp., which is more than the power eventually to be developed at Muscle Shoals. According to a statement by Thomas W. Martin, president of the company, the power from the Mitchell dam, now under construction on the Coosa River, will be entirely absorbed within a year or two after completion of the dam, and for that reason development is now to be begun on the Tallapoosa.

The four dams on the Tallapoosa, with their total of 140,000 hp., will develop 20,000 hp. more than the Mitchell dam and 30,000 hp. more than the dam at Lock Thirteen. With the completion of the Tallapoosa project the Alabama Power Company's installed power will total 435,000 hp. This includes 50,000 steam horsepower at the Gorgas plant and 15,000 steam horsepower at Gadsden, Ala.

### Canada Shows Indifference to St. Lawrence Project

To overcome Canadian apathy toward the proposed St. Lawrence River project, some changes in the plan proposed by the International Joint Commission must be made, according to a belief held in official circles in Washington. The President's interest in this project is so great, however, that it is believed he will find the means of making such changes in the plan as may be necessary.

Lack of interest in Canada is attributed to the presence of railroad facilities in excess of the country's immediate needs, and to the abundance of sites where water power can be developed in small blocks at low cost. Such Canadian influence as is being asserted in favor of the St. Lawrence development is confined to the Province of Ontario and the grain-producing provinces of western Canada which could take advantage of cheaper freight rates from the head of the lakes.

## Obituary

**Charles W. Oakley**, former New Jersey State President of the National Association of Stationary Engineers, died Sept. 6 at his home in Clifton, N. J., after a long illness. He was connected with the New York Belting and Packing Co. for twenty years and was prominent in improving power-plant operating conditions throughout New Jersey. His ancestors fought in the Revolution; his father, Major J. Sayre Oakley, now 96 years of age, participated in the Civil and Mexican Wars; he himself took part in the Spanish War and his son, Ralph W. Oakley, in the World War.

## Society Affairs

**Chattanooga Section, A.S.M.E.**, will elect officers at a business meeting on Sept. 19, 7:30 p.m., at the Chattanooga Manufacturers' Association Bldg.

**Plainfield Section, A.S.M.E.**, will meet Sept. 12, 8:15 p.m., at the Park Hotel. Dr. Richard Moldenke of Watchung, N. J., will give a paper on "Modern Foundry Practice."

**New Haven Section, A.S.M.E.**, will hold all day and evening sessions in conjunction with the machine-tool exhibit at Mason Laboratory, Yale University, Sept. 21-23. On Sept. 22 there will be a talk on "The Outlook for Industry" by Melville D. Liming, secretary of the Boston Chamber of Commerce.

**Erie (Pa.) Section, A.S.M.E.**, will meet at 8 p.m., Sept. 21, at the Public Library. Mr. Greoger, former secretary, having recently returned from Germany, will speak on "Conditions Abroad of General Interest."

**The Western Massachusetts sections, A.S.M.E.**, will hold a regional meeting Sept. 25-27 at Springfield. The Monday morning session, Sept. 25, will be a session on power; at the Monday afternoon session there will be papers on the paper industry. On Tuesday morning there will be simultaneous sessions on textiles and tools; in the afternoon, excursions to the Strathmore Paper Mill and the Fisk Rubber Co., and on Wednesday an automobile excursion to various hydro-electric plants in the Connecticut Valley.

## Business Items

**D. C. Griffiths** and **D. B. Graze** have opened offices in the Marshall Bldg., Cleveland, Ohio, as manufacturers' agents, to handle the state distribution of electrical material for the M. B. Austin Co., Appleton Rubber Co., and portions of the state for the S. H. Couch Co., Inc.

**Celite Products, Ltd.**, has been established in Canada to market Sil-O-Cel and Filter-Cel, produced by the Celite Company in the United States. Sil-O-Cel is a high-temperature insulation used for the prevention of excessive heat loss from boilers, furnaces, etc. It is furnished in brick, block, powder and cement forms, and may be applied to all types of heated equipment without change in design. Filter-Cel is used as an aid in filtering to secure greater clarity and brilliance of filtrate. Stocks of these materials will be maintained in Montreal. Lawrence Russel has been appointed manager, with offices in the New Birks Bldg.

## Fuel Prices

### BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

| Coal | Market Quoting | Aug. 28, 1922 | Sept. 5, 1922 |
|---|---|---|---|
| Pool 1, | New York | | |
| Smokeless, | Columbus | $4.00–7.50 | $4.50–6.50 |
| Clearfield, | Boston | 5.50–6.25 | 4.50–5.50 |
| Somerset, | Boston | 5.50–6.50 | 4.50–6.00 |
| Kanawha, | Columbus | 3.75–7.50 | 4.50–6.75 |
| Hocking, | Columbus | 4.00–7.75 | 5.00–5.50 |
| Pittsburgh No. 8 | Cleveland | 5.00–5.50 | 5.00–5.50 |
| Franklin, Ill., | Chicago | 4.50–4.75 | 4.50–4.75 |
| Central, Ill., | Chicago | 4.25–5.00 | 4.25–4.75 |
| Ind. 4th Vein, | Chicago | 4.65–5.00 | 4.65–5.00 |
| West Ky., | Louisville | 4.50–5.50 | 4.00–4.50 |
| Big Seam, | Birmingham | 4.00–5.00 | 3.50–4.50 |
| S. E. Ky., | Louisville | 4.50–5.75 | 4.50–5.50 |

### FUEL OIL

**New York**—Sept. 7, Port Arthur light oil 22@25 deg. Baumé 4c. per gal.; 30@35 deg., 5c. per gal, f.o.b. Bayonne, N. J.

**Chicago**—Aug. 31, for 24@26 deg. Baumé, $1.50 per bbl.; 32@36 deg., 3½c. per gal. in tank cars. f.o.b. Oklahoma refinery, or freight adjusted.

**Pittsburgh**—Aug. 22, f.o.b. refinery, Pennsylvania, 36@40 deg., 6@6¼c.; Kentucky fuel oil, 26@30 deg., 4½c. per gal.; Gas oil. 32@34 deg., 2¾c. per gal.; 36@38 deg., 3c.; 38@40 deg. 3¼c.; Western, 24@30 deg., $1.35@$1.40 per bbl.

**Philadelphia**—Sept. 1, 26@28 deg. Baumé, Oklahoma, $1.25@$1.30 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@ 3½c. per gal.; 16@20 deg. Seaboard, $1.50@$1.60 per bbl.

**Cincinnati**—Aug. 21, for 26@28 deg. Baumé, 5½s.; Diesel, 28@30 deg. 5½c. per gal.; distillate 38@40 deg., 6c.

**Cleveland** — Aug. 21, 26@28 deg. Baumé, 4¼c. per gal.

# New Plant Construction

### PROPOSED WORK

**Ark., Poyen**—A. B. Cunningham is in the market for equipment for proposed saw mill and power house, which were recently destroyed by fire.

**Calif., Los Angeles**—The Paumie-Cook Co., A. Cook, Purch. Agt., 1696 West Washington St., is in the market for a 30 hp. boiler.

**Calif., Oakland**—G. Clark, c/o W. Knowles, Archt., Hearst Bldg., San Francisco, is having plans prepared for a 3 story, 100 x 124 ft. store and loft building on Broadway. Estimated cost $300,000. E. L. Souls, Rialto Bldg., and Leland & Haley, 58 Sutter St., San Francisco, Engrs.

**Calif., Sacramento**—The city, H. G. Denton, Clk., received bids for the construction of rapid sand filtration plant and appurtenances, from K. E. Parker Co., 519 California St., and Healy-Tibbits Co., 9 Main St., San Francisco, joint bidders, $860,000; R. McLeran & Co., Hearst Bldg., San Francisco, $843,318; Matthews Constr. Co., Forum Bldg., $771,957. Noted Aug. 1.

**Calif., San Francisco**—The city and county of San Francisco plans an election about Nov. 21 to vote $1,500,000 bonds, to finance extensions to Municipal railway system. M. M. O'Shaughnessy, City Hall, Engr.

**Col., Denver**—Briscoe, Fisher & Fisher, Archts., U. S. Nat'l. Bank Bldg., will receive bids until Sept. 15 for a hospital on 9th Ave., and Colorado Blvd., for the University of Colorado, T. L. Wilkinson, Boston Bldg., Chairman. Estimated cost $1,250,000. Noted June 7, 1921.

**Fla., Vero**—The city voted $50,000 bonds for additions to electric power plant, including oil engine, switchboard, etc. Carter & Damrow, Engrs.

**Ill., Chicago**—The Chicago Trust Co., c/o Holabird & Roche, Archts., 104 South Michigan St., will soon award the contract for a 14 story, addition to bank and office building, including steam heating system, on Clark and Monroe Sts. Estimated cost $1,000,000.

**Ill., Chicago**—E. Doerr, c/o W. P. Doerr, Archt., 28 East Jackson Blvd., plans to build a 7 story 120 x 227 ft. apartment hotel, including steam heating system, on South Shore Drive. Estimated cost $500,000.

**Ind., Indianapolis**—The Enquirer Printing & Pub. Co., 309 East Ohio St., is receiving bids for a 3 story 85 x 93 ft. printing plant on East Ohio St. Estimated cost $225,000.

**Ia., Dubuque**—The city, c/o O. E. Carr, City Hall, will soon receive bids for two 1,750 cu.ft. air compressors and two 300 hp. water tube boilers for the waterworks department. Mead & Seastone, State Journal Blk., Madison, Wis., Engrs. Noted May 9.

**Mich., Grand Rapids**—The Dept. Pub. Service, G. T. Wagner, Dir. City Hall received bids for furnishing and installing two 500 hp. boilers at the city pumping plant, (a) 225 lb. pressure, (b) 160 lb. pressure, from the Springfield Boiler Co., Springfield, Ohio, (a) and (b) $15,800; Oil City Boiler Co., Detroit, (a) $18,235 (b) $15,508; Murray Iron Works Co., 880 Washington St., Burlington, Ia., (a) $16,995 (b) $15,995; J. P. Skeldon Engr. Co., 242 Water St., Toledo, Ohio, (a) $16,400 (b) $16,050; J. F. Davis & Sons Co., Chicago, Ill., (a) $17,010 (b) $16,250. Noted July 11.

**Mich., Muskegon**—The Bd. Educ. is having plans prepared for a Junior college. Estimated cost $700,000. H. H. Turner, Michigan Trust Bldg., Grand Rapids, Archts.

**Mich., Port Huron**—The Bd. Educ. will receive bids until Sept. 23 for a 3 story, 116 x 268 ft. school, including steam boiler and accessories. Estimated cost $250,000. Van Leyen, Schilling, Keough & Reynolds, 3440 Cass Ave., Detroit, Archts. Noted July 18.

**Minn., East Grand Forks**—The city, A. N. Briggs, Clk., will receive bids until Sept. 18 for 1 raw water and 1 clear water motor-driven centrifugal pumps. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, engr.

**Minn., Minneapolis**—The Duley Meat Co., 725 Hennepin Ave., is in the market for refrigeration machinery.

**N. Y., Rochester**—The Mertz Milk Co., 419 Hawley St., is in the market for refrigerator equipment for building now under construction.

**N. Y., Rochester**—The Rochester Gas & Electric Corp., plans additions and alterations to Station 26. Estimated cost $20,000. Private plans.

**N. Y., Saranac Lake**—The Bd. Educ., plans election to vote $400,000 bonds for a high school. C. B. Cutler, c/o owner, Archt.

**N. Y., Syracuse**—The Intercepting Sewer Bd., H. J. Hamlin, Secy., 104 City Hall, will receive bids until Oct. 10 for machinery and equipment for sewage pumping station and grit chamber, including switchboard and control mechanisms, four 24 in. horizontal shaft centrifugal pumps direct connected to 75 hp. variable speed a.c. motors, auxiliary vacuum priming pumps and sump pump, a 10 kw. motor generator set, cast iron suction and discharge piping with 24 in. hydraulically operated gate valves, one 54 in. and three 48 in. by 51 in. electrically operated sluice gates, a 7½ ton hand operated traveling crane, with permission to use same during erection and a grit cleaning mechanism, consisting of tramrail with electrically operated hoist and ¾ cu.yd. clamshell bucket and all necessary wiring and piping connections. Equipment to be erected on concrete foundation provided by the Board under separate contract.

**N. C., Fayetteville**—The city plans improvements and extensions to waterworks and sewerage system to cost about $250,000; also considering the construction of a municipal power plant. W. C. Olsen, Kinston, Consult. Engr.

**Ohio, Hillsboro**—The Bd. Trustees Pub. Affairs, J. Winegardner, Clk., will receive bids until Sept. 15 for waterworks improvements, including addition to building, fuel oil engine, 150 hp. direct clutch, connected to air compressor, capacity 475 cu.ft. free air per min. and vertical triplex plunger water pump, capacity 750 g.p.m. against 335 ft. head, drilling new water well, equipping and connecting 3 water wells to compressor, pump and reservoir and a 500,000 gal. storage reservoir. G. Champe, 610 Nasby Bldg., Toledo, Engr.

**Pa., Altoona**—The Blair Ice & Cold Storage Co., F. H. Sietz, Pres., 3124 Fifth Ave., is in the market for mechanical equipment for proposed ice and cold storage plant. Noted Sept. 5.

**Pa., Phila.**—W. Hering, 112 North 12th St., will soon receive bids for 8 story, 47 x 69 and 60 x 70 ft. store and office buildings at 114 North 12th St. Estimated cost $500,000. Ballinger Co., 12th and Chestnut Sts., Archts.

**Pa., Phila.**—The Venango Realty, c/o L. B. Rothchild, Archt., 1225 Samsom St., will soon award the contract for a 3 story, 39 x 105 ft. apartment building, including vapor heating system, on 21st and Venango Sts. Estimated cost $250,000.

**Pa., Sharon**—The Valley Packing & Provision Co., plans to enlarge refrigeration plant and is in the market for machinery and equipment.

**S. D., White River**—The city voted $25,000 bonds for hydro-electric plant, construction of dam, 100 ft. long 12 ft. high and a dike 200 ft. long in the White River here, also power house.

**Tex., San Antonio**—The Southwest Texas Baptist Hospital is having sketches made for a 4 story, 80 x 145 ft. hospital (first unit) on Nolan St. Estimated cost $400,000; total cost $1,000,000. W. N. Noonan, Moore Bldg., Archt.

**Va., Richmond**—The Dept. Pub. Utilities, E. W. Trafford, Dir., plans improvements to city water works, including new booster pumping station to contain pumps with 30,000,000 gals. per day capacity, improve water conditions on the South side, which includes Woodland Heights and the Forest Hill sections. Bids will be received until Sept. 14 for pump house machinery and equipment, including hydraulic turbines, 1,800 hp. electric generators, switchboards, centrifugal pumps and motors.

**Wash., Seattle**—The Alaskan Engineering Comn., Purch. Agt., 422 Bell St., Terminal, will receive bids until Sept. 17 for furnishing railroad crossings, heaters, multivane fans, pipe and fittings, steam casing, electrical equipment, etc.

**Wash., Spokane**—A. Held, Archt., 618 Realty Bldg., will receive bids until Oct. 1 for two 100 hp. boilers, for the Spokane Bakery Co., North 803 Post St.

**Wis., Bear Creek**—Flanagan Bros. are in the market for refrigeration machinery.

**Wis., Milwaukee**—The M. Hilty Lumber Co., 12th St., is having plans prepared for a 3 story 102 x 113 ft. factory and power house at the Grand Ave. viaduct. Cahill & Douglas, 217 West Water St., Engrs., will prepare specifications and receive bids for 250 kw. generator, 500 hp. engine and two 15 hp. boilers.

**Wis., Portage**—R. E. York having plans prepared for boiler and steam heating plant for store and office building. Balch & Lippert, 303 Gay Bldg., Madison, Engrs.

**Alta., Calgary**—The Imperial Oil, Ltd., Regina, Sask., plans to build a refinery on Bow River, here, capacity 3,500 bbls. Estimated cost $2,500,000. Engineer not announced.

**Alta., Vermillion**—The Vermillion Dairy Co., Ltd., C. B. Johnston, Purch. Agt., c/o Edmonton City Dairy, Ltd., Edmonton, is in the market for a boiler and engine.

**Ont., Chesley**—The Bruce Woodworkers, Ltd., are in the market for a 30 hp. 3 phase, 60 cycle, 220 volt motor.

**Ont., Forest**—The council is having revised plans prepared for waterworks system, including pump house and mains. Estimated cost $35,000. Prices wanted on materials and equipment. Chipman & Power, Mail Bldg., Toronto, Engrs. Noted June 13.

**Ont., Galt**—Cameron & Ralston, Archts., Bartlett Bldg., Windsor, will receive bids until Sept. 16 for a 3 story collegiate school, including steam heating and mechanical ventilating systems, for the Bd. Educ., A. McBean, Secy. Estimated cost $300,000. Noted May 23.

**Ont., Ottawa**—The city, N. H. H. Lett, Clk., is receiving bids for boilers and stokers for $2,500,000 hospital. Stevens & Lee, 62 Charles St., E. Toronto, Archts.

**Ont., Port Arthur**—The Thunder Bay Paper Co., c/o J. E. Schnabel, Gen'l. Purch. Agt., Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., is in the market for three 650 kva. 40 deg. 257 r.p.m., 550 volt horizontal synchronous pulp grinding motors; three 1,200 kva. 60 cycle 22,000 volts, primary, 550 volts secondary, oil filled, water cooled transformers; two 75 hp. 720 r.p.m. 550 volt, 3 phase, 60 cycle 50 deg. vise slip ring type motors and one 75 kw. d.c. generator.

**Ont., Toronto**—The Bd. of Control, C. A. Maguire, Mayor, will receive bids until Oct. 3 for two 2,800,000 Imp. gal. centrifugal pumps and motors for sewage plant. R. C. Harris, City Hall, Engr.

## CONTRACTS AWARDED

**Ill., Chicago**—H. Minkus, c/o Leichenko & Esser, Archts., 38 South Dearborn St., awarded the contract for a 4 story 70 x 121 ft. store and apartment building on Broadway and Roscoe Sts., to the Waldman Constr. Co., 105 North Clark St. Estimated cost $275,000. Steam heating system will be installed.

**Ill., Chicago**—The Stony Island Trust & Savings Bank, 6822 Stony Island Ave., awarded the contract for an 8 story 65 x 115 ft. bank on 68th St. and Stony Island Ave., to F. Burke, 35 South Dearborn St. Estimated cost $500,000. Steam heating system will be installed.

**Mass., Medford**—The Lawrence Memorial Hospital, Governors Ave., awarded the contract for a 3 story, 50 x 150 ft. hospital, and a 3 story 40 x 60 ft. service building, to the Evatt Constr. Co., 161 Devonshire St., Boston. Estimated cost $200,000. Steam heating system will be installed.

**Mass., Worcester**—The Printers Bldg. Trust, Portland St., awarded the contract for a 7 story, 100 x 135 ft. mercantile building, to the E. J. Cross Co., 82 Foster St. Estimated cost $350,000. Steam heating system will be installed.

**Mich., Detroit**—The Clifford Land Co., c/o J. P. Jogerst, Archt., 1127 Shelby St., awarded the contract for a 10 story, 150 x 171 ft. apartment building on Clifford St., to the National Constr. Co., 1031 Dime Bank Bldg. Estimated cost $1,500,000. Vapor steam heating equipment and washed air ventlating device, will be installed. Noted May 9.

**Mich., Detroit**—G. Klein, c/o A. Kahn, archt., 1000 Marquette Bldg., awarded the contract for an 8 story, 107 x 111 ft. apartment building on Pingree Ave., to Bryant & Detwiler, 2336 Dime Bank Bldg. Estimated cost $400,000. Steam heating equipment, including boiler, will be installed. Noted July 11.

**Mich., Jackson**—The Hayes Wheel Co., Jackson and Douglas Sts. awarded the contract for a 1 story 50 x 60 and 100 x 160 ft. power house and factory, to the H. K. Ferguson Co., 6523 Euclid Ave., Cleveland, Ohio. Estimated cost $250,000.

**Mich., Menominee**—The Wisconsin Pub. Service Corp., J. P. Pulliam, Secy., 559 Marshall St., Milwaukee, awarded the contracts for new unit and improvements to electric power plant to J. R. McDonald, Black River Falls, power machinery to the Allis-Chalmers Co., West Allis. Noted July 25.

**N. Y., New York**—The Intercollegiate Cosmopolitan Club, 2929 Bway., awarded the contract for a 9 story, 128 x 168 ft. clubhouse at 520 Riverside Dr., to Marc Eidlitz & Son, Inc., 41 East 42nd St. Estimated cost $750,000.

**N. C., Charlotte**—The city awarded the contracts for the construction of a filtration plant as follows: general, to Tucker & Laxton, Realty Bldg., $201,425; gate valves, Grinnell Co., $15,303; 2 Venturi meters, Builders Iron Foundry, 9 Codding St., Providence, R. I., $3,234; tower and tank, surge tank and wash water tank, R. D. Cole Mfg. Co., $45,500. Contracts for pumps, estimated cost $20,000, will be awarded later. Noted Aug. 15.

**Ohio, Alliance**—The Crescent China Co., awarded the contract for a 1 story 140 x 700 ft. factory to the H. K. Ferguson Co., 16521 Euclid Ave., Cleveland. Estimated cost $250,000.

**Ohio, Oxford**—The Miami University, Bd. Trustees, awarded the contracts for a 3 story woman's dormitory, to J. Lowes, 509 West 2nd St., Dayton, $187,770, heating and plumbing to the Walker Constr. Co., Hamilton, $26,580.

**Pa., Phila.**—The Bd. Pub. Health, City Hall, awarded the contract for 1½ story, 35 x 148 ft. sanitarium on Byberry Ave., to the Geo. H. Evans Co., 109 North 13th St., $119,430. Estimated cost of plumbing and heating, about $30,600.

**Pa., Pittsburgh**—The Hardie Bros., 1601 Liberty Ave., awarded the contract for a 5 story, 100 x 325 ft. candy factory on 14th and Pike Sts., to Feltyberger & Reed, Peoples Bank Bldg. Estimated cost $350,000.

**Tex., San Antonio**—The State Bd. Control, Austin, awarded contracts for improvements to the Southwestern Insane Asylum, as follows: power house, to Coleman & Jenkins, Gunter Bldg., $25,989, oil storage tank, to W. W. Lehr, South Medina St., $2,315, smoke stack to Sumner & Sollet, Nat'l. Bank of Commerce, $3,600. Noted Aug. 29.

**Wis., Green Bay**—Sisters of Our Lady of Charity, c/o Good Shepherd Home, awarded the contract for 1 story 86 x 200 ft. laundry and 36 x 120 ft. boiler house, to H. Danischefsky, 1484 Humboldt Ave., Milwaukee. Estimated cost $70,000. Laundry equipment will be installed.

**Wis., Madison**—The city, H. C. Buser, Clk., awarded the contract for pumping and sewage disposal machinery and equipment for power house at Monona Park, to the Duro Pump & Mfg. Co., 6 South Jefferson St., Dayton, Ohio. Noted Aug. 8.

**Wis., Madison**—The University of Wisconsin, Bd. Regents, M. E. McCaffery, Secy., awarded the contract for a 7 story, 250 x 300 ft. state hospital on Charter St., to the Immel Constr. Co., 200 North Main St., Fond du Lac, $668,443. Noted Dec. 17, 1921.

**Wis., Rosendale**—The Central Wisconsin Canning Co., Beaver Dam, awarded the contract for 2 story 60 x 180 ft. warehouse, 3 story 50 x 80 ft. manufacturing building, 40 x 50 ft. boiler house and two 1 story 30 x 40 ft. buildings, to the Hutter Constr. Co., 128 Western Ave., Fond du Lac. Estimated cost $75,000. Two 150 hp. boilers, 2 steam engines and several electric motors, canning and conveying machinery will be installed.

**Ont., London**—The Western University, A. T. Little, Pres., awarded the contract for a 3 story, 175 x 300 ft. science building on the university grounds, to J. Putherbough, 1006 Wellington St. Estimated cost $250,000. A central steam heating plant will be built later. Noted Aug. 22.

**Ont., Woodbridge**—The city council awarded the contract for a pumping plant waterworks and mains to the Standard Constr. Co., Mimico. Estimated cost $30,000. Prices wanted on gasoline driven equipment. Noted Mar. 21.

**H. T., Honolulu**—The Queen's Hospital Ass'n., awarded the contract for a 3 story hospital, to the Ingvorsen Constr. Co., about $375,000.

# PRICES - MATERIALS - SUPPLIES

**Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.**

## SINCE LAST MONTH

**Advances**—Structural steel, $3.04 as against $2.83 per 100 lb., in New York warehouses, one month ago. Rivets and cold finished steel also advanced in New York, Cleveland and Chicago. Wrought pipe discounts reduced three points on black steel and two on galvanized; five points on black iron and nine on galvanized, on new Pittsburgh basing card of Aug. 23. Lapweld steel boiler tubes, 1¾-in., up 7c.; c.c. iron, 8c and seamless steel, 6c. per lin.ft., in New York warehouses. Portland cement, $2.60 as against $2.40@$2.50 per bbl., delivered in New York. Cotton waste, 1½c. per lb. higher in New York. All refractories advanced; chrome brick up $3, magnesite, $4@$6 per net ton; Silica, $10@$12 and clay, $2 per 1,000.

**No Declines** in electrical or power-plant supplies.

## POWER-PLANT SUPPLIES

**HOSE—**

| | Fire | 50-Ft. Lengths |
|---|---|---|
| Underwriters' 2½-in., coupled | | 49½c. per ft. |
| Common, 2½-in., 3-ply | 1.00 per ft. list less 50% | |

| | Air | |
|---|---|---|
| | First Grade | Second Grade |
| ¾-in., 3-ply, per ft. | $0.31 | $0.22½ |

Steam—Discounts from List

First grade....40–10% Second grade...50–5% Third grade....50–10–5%

**RUBBER BELTING**—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–10–5% Best grade..... 60–5%

**LEATHER BELTING**—List price per ply, 12-in. wide, per lin. ft. $2.88

| Grade | Discount from list |
|---|---|
| Medium | 40–5% |
| Heavy | 30–5% |

**RAWHIDE LACING**—For cut, best grade, 50–5%, 2nd grade, 55–5%. For laces in sides, best, 45c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 45–5%; sides, 47c. per sq.ft.

**PACKING**—Prices per pound:

| | |
|---|---|
| Rubber and duck for low-pressure steam, ⅛ in. | $0.90 |
| Asbestos for high-pressure steam, ⅛ in. | 1.80 |
| Duck and rubber for piston packing | .90 |
| Flax, regular | 1.10 |
| Flax, waterproofed | 1.70 |
| Compressed asbestos sheet | .90 |
| Wire insertion asbestos sheet | 1.30 |
| Rubber sheet | .45 |
| Rubber sheet, wire insertion | .70 |
| Rubber sheet, duck insertion | .50 |
| Rubber sheet, cloth insertion | .30 |
| Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes | 1.40 |
| Asbestos wick, ½- and 1-lb. balls | .70 |

**PIPE AND BOILER COVERING**—Discounts, New York warehouses, are as follows:

| | | |
|---|---|---|
| 85% magnesia high pressure | | 60% off |
| For low-pressure heating and return lines | 4-ply | 70% off |
| | 3-ply | 72% off |
| | 2-ply | 74% off |

**PORTLAND CEMENT**—New York, $2.60 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

**STRUCTURAL STEEL**—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.04 per 100 lb.

**COTTON WASTE**—The following prices are in cents per pound:

| | New York Current | Cleveland | Chicago |
|---|---|---|---|
| White | 9.00@11.50 | 12.00 | 11.25 |
| Mixed | 6.50@10.00 | 9.00 | 8.00 |

**WIPING CLOTHS**—Jobbers' prices, in cents per lb., as follows:

| | 13¼ x 13¼ | 13½ x 20½ |
|---|---|---|
| Cleveland | 10.00 | 11.00 |
| Chicago | 10.00 | 13.00 |
| New York | 7.50 | 8.00 |

**LINSEED OIL**—These prices are per gallon:

| | New York | Cleveland | Chicago |
|---|---|---|---|
| Raw in barrels (5 bbl. lots) | $0.91 | $1.14 | $0.99 |

**WHITE AND RED LEAD**—Base price per pound:

| | Red—Current | | Red—1 Year Ago | | White—Current | | White—1 Yr. Ago | |
|---|---|---|---|---|---|---|---|---|
| | Dry | In Oil | Dry | In Oil | Dry or In Oil | Dry or In Oil | | |
| 100-lb. keg | 12.50 | 14.00 | 12.25 | 13.75 | 12.50 | 12.25 | | |
| 25- and 50-lb. keg | 12.75 | 14.25 | 12.50 | 14.00 | 12.75 | 12.50 | | |
| 12½-lb. keg | 13.00 | 14.50 | 12.75 | 14.25 | 13.00 | 12.75 | | |
| 5-lb. cans | 15.50 | 17.00 | 15.25 | 16.75 | 15.50 | 15.25 | | |
| 1-lb. cans | 17.50 | 19.00 | 17.25 | 18.75 | 17.50 | 17.25 | | |

**RIVETS**—The following quotations are allowed for fair-sized orders from warehouse:

| | New York | Cleveland | Chicago |
|---|---|---|---|
| Steel ⅞ and smaller | 55% | 65% | 60% |
| Tinned | 55% | 65% | 4½c. per lb. net |

Structural rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York....$3.85 Chicago....$3.35 Pittsburgh..$2.65@$3.00

Boiler rivets, same sizes:

New York....$3.95 Chicago....$3.45 Pittsburgh..$2.75@$3.10

**REFRACTORIES**—Prices in carlots:

| | | |
|---|---|---|
| Chrome brick, eastern shipping points | net ton | $45@48 |
| Chrome cement, 40@45% $Cr_2O_3$ | net ton | 27@30 |
| Chrome cement, 40@45% $Cr_2O_3$, in sacks | net ton | 30.50@32.50 |
| Magnesite brick: 9-in. shapes | net ton | 60@62 |
| Magnesite brick: 9-in. arches, wedges and keys | net ton | 66@68.20 |
| Magnesite brick: Soaps and spits | per ton | 84@86.80 |
| Silica brick: Chicago district | per 1,000 | 50@53 |
| Silica brick: Birmingham, Ala. | per 1,000 | 52@55 |
| Silica brick: Mt. Union, Pa. | per 1,000 | 45@47 |
| Chrome ore crude, 45@50% | net ton | 20@22 |
| Magnesite dead burn (Imported) | net ton | 33@35 |
| Clay brick, 1st qulity, 9-in. shapes, Missouri | per 1000 | 40@45 |
| Clay brick, 1st quality, 9 in. shapes, Pennsylvania | per 1000 | 35@38 |
| Clay brick, 1st quality, 9 in. shapes, Ohio | per 1000 | 35@38 |
| Clay brick, 1st quality, 9 in. shapes, Kentucky | per 1000 | 35@38 |
| Clay brick, 2nd quality, 9-in. shapes, Missouri | per 1000 | 30@35 |
| Clay brick, 2nd quality, 9 in. shapes, Pennsylvana. | per 1,000 | 31.50@35 |
| Clay brick, 2nd quality, 9 in. shapes, Ohio | per 1,000 | 31.50@35 |
| Clay brick, 2nd quality, 9 in. shapes, Kentucky | per 1,000 | 31.50@35 |

**BABBITT METAL**—Warehouse prices in cents per pound:

| | New York | Cleveland | Chicago |
|---|---|---|---|
| Fair grade | 24.50 | 42.75 | 36.00 |
| Commercial | 11.12½ | 16.00 | 9.00 |

**COLD FINISHED STEEL**—Warehouse prices are as follows:

| | New York | Chicago | Cleveland |
|---|---|---|---|
| Round shafting and screw stock, per 100 lb. base | $3.65 | $3.70 | $3.45 |
| Flats, square and hexagons, per 100 lb. base | 4.15 | 4.20 | 3.95 |

**BOILER SPECIALTIES**—F. o. b. **New York** or **Jersey City**, discounts on list:

| | Current |
|---|---|
| Copper ferrules | 70% |
| Boiler flanges | 60-10% |
| Boiler stay bolts | 60% |
| Boiler patch bolts | 10% |
| Boiler fitting-up bolts | 60% |
| Pressed steel boiler lugs | 10% |
| Pressed steel boiler hangers | 10% |

**WROUGHT PIPE**—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

| Inches | Steel Black | Steel Galv. | Inches | Iron Black | Iron Galv. |
|---|---|---|---|---|---|
| 1 to 3 | 68 | 56½ | ¼ to 1¼ | 39½ | 24½ |

LAP WELD

| | | | | | |
|---|---|---|---|---|---|
| 2 | 61 | 49½ | 2 | 34½ | 20½ |
| 2½ to 6 | 65 | 53½ | 2½ to 4 | 37½ | 24½ |
| 7 to 8 | 62 | 49½ | 4½ to 6 | 37½ | 24½ |
| 9 and 12 | 61 | 48½ | 7 to 12 | 35½ | 22½ |

BUTT WELD, EXTRA STRONG, PLAIN ENDS

| | | | | | |
|---|---|---|---|---|---|
| 1 to 1½ | 66 | 55½ | ¼ to 1½ | 39½ | 25½ |
| 2 to 3 | 67 | 56½ | | | |

LAP WELD, EXTRA STRONG, PLAIN ENDS

| | | | | | |
|---|---|---|---|---|---|
| 2 | 59 | 48½ | 2 | 35½ | 22½ |
| 2½ to 4 | 63 | 52½ | 2½ to 4 | 38½ | 26½ |
| 4½ to 6 | 62 | 51½ | 4½ to 6 | 37½ | 25½ |
| 7 to 8 | 58 | 45½ | 7 to 8 | 30½ | 18½ |
| 9 to 12 | 52 | 39½ | 9 to 12 | 25½ | 13½ |

**BOILER TUBES**—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

| Size | Lapweld Steel | C. C. Iron | Seamless Steel |
|---|---|---|---|
| 1 | ..... | ..... | $0.21 |
| 1¼ | ..... | ..... | .23 |
| 1½ | ..... | ..... | .20 |
| 1¾ | $0.23 | $0.26 | .21 |
| 2 | .18 | .23 | .19 |
| 2¼ | .21 | .26 | .21 |
| 2½ | .22 | .30 | .25 |
| 2¾ | ..... | ..... | ..... |
| 3 | .27 | .37 | .29 |
| 3¼ | .29 | .43 | .32 |
| 3½ | .31 | .46 | .34 |
| 4 | .39 | .58 | .43 |

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

## ELECTRICAL SUPPLIES

**ARMORED CABLE**—Price per 1,000 ft.—5 per cent 10 days.

| B. & S. Size | Two Cond. M Ft. | Three Cond. M Ft. | Two Cond. Lead M Ft. | Three Cond. Lead M Ft. |
|---|---|---|---|---|
| No. 14 solid | $ 42.00 (net) | $59.00(net) | $164.00 | $210.00 |
| No. 12 solid | 135.00 | 170.00 | 225.00 | 265.00 |
| No. 10 solid | 185.00 | 235.00 | 275.00 | 325.00 |
| No. 8 stranded | 285.00 | 375.00 | 520.00 | 500.00 |
| No. 6 stranded | 400.00 | 500.00 | 560.00 | ..... |

From the above lists discounts are:

| | | |
|---|---|---|
| Less than coil lots | 40% | 20% |
| Coils to 1,000 ft. | 45% | 30% |
| 1,000 to 5,000 ft. | 50% | 35% |
| 5,000 ft. and over | 50–10% | 40% |

**CONDUIT**, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

| Size, In. | Conduit Per M | Conduit Per M | Elbows Per C | Elbows Per C | Couplings Per C | Couplings Per C |
|---|---|---|---|---|---|---|
| ¼ | $49.64 | $54.74 | $8.82 | $9.96 | $4.86 | $5.28 |
| ⅜ | 63.71 | 70.61 | 11.60 | 13.10 | 6.94 | 7.54 |
| 1 | 90.78 | 100.98 | 17.17 | 19.39 | 9.02 | 9.80 |
| 1¼ | 122.82 | 136.62 | 23.13 | 25.83 | 12.65 | 13.67 |
| 1½ | 146.85 | 163.35 | 30.84 | 34.44 | 15.62 | 16.88 |
| 2 | 197.58 | 219.78 | 56.54 | 63.14 | 20.83 | 22.51 |
| 2½ | 312.39 | 347.49 | 92.52 | 103.32 | 29.76 | 32.16 |
| 3 | 408.51 | 454.41 | 246.72 | 275.52 | 44.64 | 48.24 |
| 3½ | 518.88 | 574.08 | 544.84 | 608.44 | 59.52 | 64.32 |
| 4 | 636.56 | 701.96 | 629.65 | 703.15 | 74.40 | 80.40 |

**CONDUIT BODIES AND FITTINGS**—Black or galvanized.

| | Less than $10 list | $10 list to $100 list | $100 list and over |
|---|---|---|---|
| Standard package | 10% | 20% | 28% |
| Less than standard package | 5% | 10% | 20% |

**CUT-OUTS**—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

| | | | |
|---|---|---|---|
| S. P. M. L. | $0.08 | D. P. D. B. | $0.26 |
| D. P. M. L. | .13 | T. P. S. B. | .25 |
| T. P. M. L. | .19 | T. P. D. B. | .38 |
| D. P. S. B. | .15 | | |

CUT-OUTS, N. E. C. FUSE

| | 0-30 Amp. | 31-60 Amp. | 60-100 Amp. |
|---|---|---|---|
| D. P. M. L. | $0.38 | $1.20 | $1.25 |
| T. P. M. L. | .53 | 1.40 | 1.80 |
| D. P. S. B. | .47 | 1.20 | ..... |
| T. P. S. B. | .88 | 2.00 | ..... |
| D. P. D. B. | .85 | 2.35 | ..... |
| T. P. D. B. | 1.50 | 4.00 | ..... |
| T. P. to D. P. D. B. | 1.00 | 2.75 | ..... |

**FLEXIBLE CORD**—Price per 1,000 ft. in coils of 250 ft.:

| | |
|---|---|
| No. 18 cotton reinforced heavy | $19.95 |
| No. 16 cotton reinforced heavy | 26.15 |
| No. 18 cotton reinforced light | 17.33 |
| No. 16 cotton reinforced light | 21.50 |
| No. 18 cotton Canvasite cord | 14.70 |
| No. 16 cotton Canvasite cord | 17.06 |

**NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—**

| 250-Volt | Std. Pkg. | List | 600-Volt | Std. Pkg. | List |
|---|---|---|---|---|---|
| 3-amp. to 30-amp., | 100 | $.20 | 3-amp. to 30-amp., | 100 | $0.40 |
| 35-amp. to 60-amp., | 100 | 0 30 | 35-amp. to 60-amp., | 100 | .60 |
| 65-amp. to 100-amp., | 50 | 2.90 | 65-amp. to 100-amp., | 50 | 1.50 |
| 110-amp. to 200-amp., | 25 | 3.00 | 110-amp. to 200-amp., | 25 | 2.50 |
| 225-amp. to 400-amp., | 25 | 5.60 | 225-amp. to 400-amp., | 25 | 5.50 |
| 425-amp. to 600-amp., | 10 | .50 | 450-amp. to 600-amp., | 10 | 8.00 |

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

**RENEWABLE FUSES, ENCLOSED**—List price each:

| Sizes | 250-Volt List-Price | 600-Volt List-Price | Std. Pkg. Quantity | Carton Quantity |
|---|---|---|---|---|
| 1 to 30-amp. | $0.50 | $1.10 | 100 | 10 |
| 35 to 60-amp. | 1.00 | 1.25 | 100 | 10 |
| 65 to 100-amp. | 2.00 | 3.00 | 50 | 5 |
| 110 to 200-amp. | 4.00 | 5.00 | 25 | 5 |
| 225 to 400-amp. | 7.50 | 11.00 | 25 | 1 |
| 450 to 600-amp. | 11.00 | 16.00 | 10 | 1 |
| 450 to 600-amp. | 11.00 | 16.00 | 10 | 1 |

**REFILLS—**

| | | | | |
|---|---|---|---|---|
| 1 to 30 | $0.30 ea. | $0.05 | 100 | 100 |
| 35 to 60 | .05 ea. | .06 | 100 | 100 |
| 65 to 100 | .10 ea. | .10 | 50 | 50 |
| 110 to 200 | .15 ea. | .15 | 25 | 50 |
| 225 to 400 | .30 ea. | .30 | 25 | 25 |
| 450 to 600 | .60 ea. | .60 | 10 | 10 |

| | |
|---|---|
| Discount Without Contract—Fuses: | |
| Broken carton | 5% |
| Unbroken carton but less than std. pkg. | 22% |
| Std. pkg. | 40% |
| Discount Without Contract—Renewals: | |
| Less than std. pkg. | Net list |
| Standard package | 40% |
| Discount With Contract—Fuses: | |
| Broken cartons | 10% |
| Unbroken cartons but less than standard package | 26% |
| Standard package | 42% |
| Discount With Contract—Renewals: | |
| Less standard package | Net list |
| Standard package | 42% |

**FUSE PLUGS, MICA CAP—**

| | |
|---|---|
| 0–30 ampere, standard package | $2.40 |
| 0–30 ampere, less than standard package | 2.75 |

**LAMPS**—Below are present quotations in less than standard package quantities:

| Straight-Side Bulbs Mazda B— Watts | Plain | Frosted | No. in Package | Pear-Shaped Bulbs Mazda C— Watts | Clear | Frosted | No. in Package |
|---|---|---|---|---|---|---|---|
| 10 | $0.35 | $0.40 | 100 | 75 | $0.70 | $0.75 | 50 |
| 15 | .35 | .40 | 100 | 100 | .95 | 1.00 | 24 |
| 25 | .35 | .40 | 100 | 150 | 1.30 | 1.40 | 24 |
| 40 | .35 | .40 | 100 | 200 | 1.80 | 1.90 | 24 |
| 50 | .35 | .40 | 100 | 300 | 2.50 | 2.65 | 24 |
| 60 | .40 | .45 | 100 | | | | 12 |
| | | | | 500 | 3.75 | 3.95 | 12 |
| | | | | 750 | 5.25 | 5.50 | 8 |
| | | | | 1,000 | 6.00 | 6.35 | 8 |

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

**PLUGS, ATTACHMENT—**

| | Each |
|---|---|
| Porcelain separable attachment plug | $0.17 |
| Composition 2-piece attachment plug | .26 |
| Swivel attachment plug | .12 |

**RUBBER-COVERED COPPER WIRE**—Per 1000 ft. f. o. b. New York.

| No. | Solid Single Braid | Solid Double Braid | Stranded, Double Braid | Duplex |
|---|---|---|---|---|
| 14 | $ 6.56 | $ 8.00 | $10.02 | $15.96 |
| 12 | 8.72 | 10.60 | 12.54 | 20.84 |
| 10 | 11.44 | 13.65 | 15.96 | 27.09 |
| 8 | 15.38 | 17.90 | 21.05 | 36.22 |
| 6 | ..... | ..... | 31.81 | ..... |
| 4 | ..... | ..... | 42.94 | ..... |
| 2 | ..... | ..... | 64.99 | ..... |
| 1 | ..... | ..... | 86.83 | ..... |
| 0 | ..... | ..... | 107.78 | ..... |
| 00 | ..... | ..... | 127.89 | ..... |
| 000 | ..... | ..... | 153.66 | ..... |
| 0000 | ..... | ..... | 183.70 | ..... |

**SOCKETS, BRASS SHELL—**

| ½ In. or Pendant Cap Key Each | Keyless Each | Pull Each | ¾ In. Cap Key Each | Keyless Each | Pull Each |
|---|---|---|---|---|---|
| $0.33 | $0.30 | $0.60 | $0.39 | $0.36 | $0.66 |

| | |
|---|---|
| Less 1-5th standard package | 15% |
| 1-5th to standard package | 30% |
| Standard package | 45% |

**WIRING SUPPLIES—**

| | |
|---|---|
| Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots | 33c. lb |
| Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots | 33c. lb |
| Wire solder, less 100 lb. 27c. lb., 100 lb. lots | 21c. lb |
| Soldering paste, 2 oz. cans | $1.00 doz |

**ENCLOSED SWITCHES, KNIFE**—Externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

| Size, Amp. | Double Pole, Each | Three Pole, Each | Four Pole, Each |
|---|---|---|---|
| 30 | $4.50 | $6.00 | $7.25 |
| 60 | 7.50 | 8.25 | 10.50 |
| 100 | 10.50 | 13.00 | 22.50 |
| 200 | 16.00 | 20.00 | 36.00 |

| Discounts: | |
|---|---|
| Less than $25.00 list value | 25% |
| $25 to $50 list value | 30% |
| $50 list value or over | 35% |